FOReSiGHT

WHITEPAPER ON ALGORITHMIC GOVERNANCE

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ABOUT THIS DOCUMENT

This document is created under Project FOReSiGHT, by the project team.

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It is part of our FOReSiGHT Kit for Foreseeing and Integrating Algorithmic Governance (AG) Skills.

ts English Version may also be found on the BLOCKS Platform.
https://platform.blocks.ase.ro/

The Project

Project FOReSiGHT - Flexibility and Resilience in Digital Transformation and Intelligent Automation – Advanced Skills and Tools for Academia and Entrepreneurs.

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Disclaimer

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Table of Contents

Introduction

Purpose of the whitepaper

This whitepaper aims to provide a comprehensive and in-depth exploration of the emerging field of Algorithmic Governance (AG). This document is designed to serve as a resource for a broad audience, including policymakers, researchers, technologists, and the general public, who are interested in understanding the implications of artificial intelligence (AI) and algorithms in governance.

The primary objectives of this whitepaper are:

1. To introduce the basics of Algorithmic Governance
2. To explore the economic perspective of AI
3. To present an Algorithmic Governance Framework
4. To describe work personas in AG and a skills map of AG workers
5. To provide a European perspective on AG and AI
6. To discuss innovation in AG
7. To identify trends in Algorithmic Governance

This whitepaper aims to provide a thorough, informative, and neutral academic exploration of Algorithmic Governance. It seeks to describe the field comprehensively, offering valuable insights for anyone interested in the intersection of AI and governance.

Basics of Algorithmic Governance

Algorithmic Governance (AG) is a rapidly evolving field that focuses on the principles and practices involved in managing and regulating algorithms' design, development, deployment, and use. It encompasses two key aspects: governance of algorithms and governance by algorithms.

The **governance of algorithms** involves ensuring that algorithms are designed and used in a manner that is ethical, unbiased, and compliant with legal and regulatory frameworks. It includes considerations of transparency, accountability, and fairness in algorithmic decision-making.

On the other hand, **governance by algorithms** refers to the use of algorithms in decision-making processes. It involves ensuring that algorithmic decision-making is conducted in a manner that is ethical, fair, and accountable.

Understanding AG requires familiarity with several key frameworks and concepts. One such framework is the concept of 'algorithmic accountability', which refers to the idea that entities (individuals, organizations, or governments) should be held accountable for the outcomes of their algorithmic systems. This involves ensuring that algorithms are transparent, that their decision-making processes can be understood and scrutinized, and that any harm or biases they cause can be identified and addressed.

Another important concept in AG is 'algorithmic fairness', which ensures that algorithms do not perpetuate or exacerbate existing social inequalities. This requires careful consideration of how data is collected and used and ongoing monitoring and auditing of algorithmic systems.

Finally, 'algorithmic transparency' is a crucial aspect of AG. This involves making the workings of algorithms understandable to those affected by their decisions. It includes providing clear explanations of how algorithms make decisions and enabling individuals to challenge decisions made by algorithms.

Understanding these frameworks and concepts is crucial for anyone seeking to navigate the complex landscape of AG. By equipping individuals with the knowledge and skills to govern algorithms effectively, AG plays a vital role in promoting responsible innovation and the use of technology in the digital age.[1]

What is Algorithmic Governance?

[1] https://journals.sagepub.com/doi/full/10.1177/2053951717726554

Algorithmic governance refers to the use of artificial intelligence (AI) and machine learning (ML) techniques to support decision-making processes in various domains, including finance, healthcare, education, and public policy. These systems can help organizations make better decisions by analyzing large amounts of data to identify patterns and provide insights.

However, algorithmic governance also raises ethical and social concerns, particularly when it comes to issues such as bias, fairness, transparency, and accountability. As a result, there is a growing need for managers to understand how these systems work and to develop strategies for ensuring that they are used ethically and responsibly.

Principles of Algorithmic Governance

The principles of algorithmic governance are based on the idea that these systems should be designed to serve the public interest and promote human well-being. The following are some of the key principles that guide algorithmic governance:

- **Fairness**: Algorithmic decision-making systems should treat all individuals and groups fairly and without discrimination.
- **Transparency**: The decision-making process should be transparent, meaning that users should be able to understand how the system arrived at its conclusions.
- **Accountability**: Organizations should be accountable for the outcomes of algorithmic systems and should have mechanisms in place for addressing errors or biases.
- **Privacy**: Personal data should be protected and only used for legitimate purposes.
- **Human oversight**: Algorithms should not replace human judgment entirely, and there should be human oversight over the decision-making process.
- **Social impact**: The potential social impact of algorithmic systems should be considered and evaluated before implementation.

Benefits and Challenges of Algorithmic Governance

Algorithmic governance has the potential to provide significant benefits, such as increased efficiency, accuracy, and consistency in decision-making processes. For example, algorithms can help healthcare organizations identify patients who are at high risk of developing certain conditions and provide targeted interventions to prevent illness.

However, there are also several challenges associated with algorithmic governance. One of the main concerns is the potential for bias and discrimination in decision-making processes. This can occur when algorithms are trained on biased data or when they use factors that are correlated with protected characteristics, such as race or gender, to make decisions.

Another challenge is the lack of transparency and accountability in some algorithmic systems. For example, some credit-scoring algorithms are opaque, making it difficult for users to understand how their scores are calculated and how they can improve them. Additionally, there may be limited legal or regulatory frameworks in place to ensure that these systems are used ethically and responsibly.

Ethical and Legal Issues in Algorithmic Governance

Bias and Fairness

One of the main concerns with algorithmic decision-making systems is the potential for bias and unfairness. This can occur when algorithms are trained on biased data or use factors that are correlated with protected characteristics, such as race or gender, to make decisions.

For example, a study found that a popular algorithm used to predict recidivism in criminal defendants was biased against African American defendants. The algorithm was more likely to incorrectly label African American defendants as high-risk for future crimes than it was to incorrectly label white defendants.

To address these issues, organizations need to ensure that their algorithms are trained on unbiased data and do not use factors that are correlated with protected characteristics.

Privacy and Security

Another important concern with algorithmic governance is privacy and security. Many algorithms use personal data to make decisions, which can raise privacy

concerns if the data is not properly protected. Additionally, algorithmic systems can be vulnerable to cyber attacks, which can compromise sensitive data.

To address these challenges, organizations need to ensure that they have proper data protection measures in place, such as encryption and secure data storage. They also need to ensure that they comply with relevant data protection regulations, such as the General Data Protection Regulation (GDPR) in the European Union.

Accountability and Transparency

Algorithmic decision-making systems can also raise concerns about accountability and transparency. Since these systems can be opaque, it can be difficult for users to understand how decisions are made and to challenge decisions that may be incorrect or unfair.

To address these issues, organizations need to ensure that they have mechanisms in place for users to challenge decisions made by algorithms. Additionally, organizations should strive to make their algorithms transparent and explainable, so that users can understand how decisions are made.

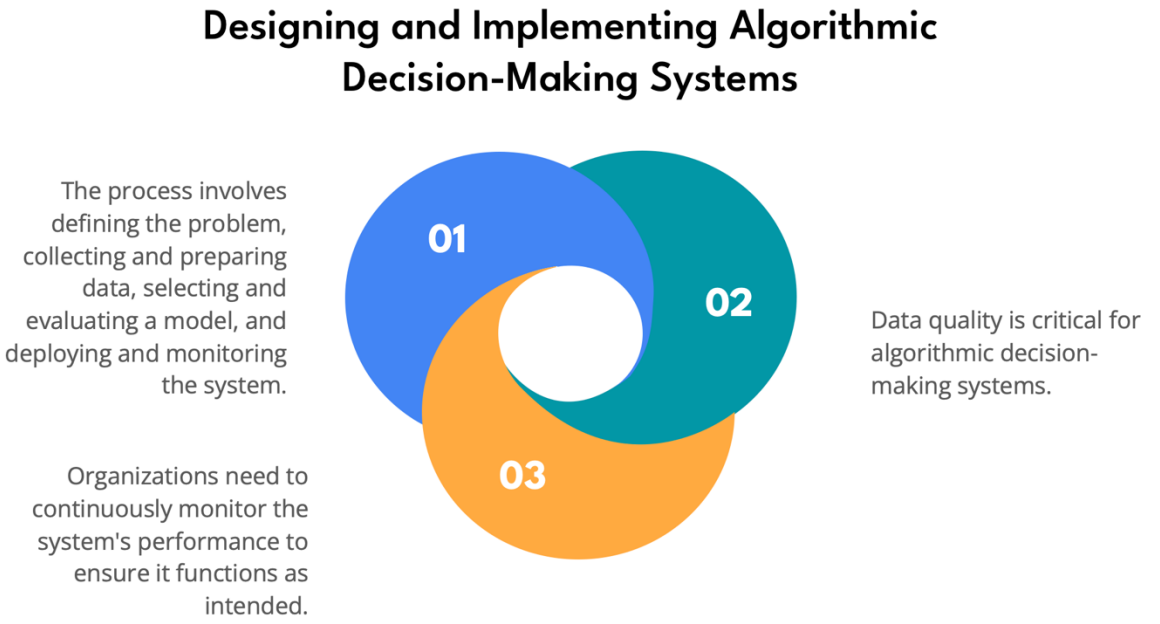
Legal and Regulatory Frameworks

Algorithmic governance is subject to a range of legal and regulatory frameworks, which vary depending on the domain and jurisdiction. For example, in the United States, algorithmic decision-making systems are subject to several federal laws, such as the Fair Credit Reporting Act and the Americans with Disabilities Act.

In the European Union, the General Data Protection Regulation (GDPR) sets out requirements for data protection and privacy that apply to all organizations that collect or process personal data.

Organizations need to ensure that they comply with relevant legal and regulatory frameworks and take into account the potential legal risks associated with algorithmic decision-making.

Designing and Implementing Algorithmic Decision-Making Systems



Defining the Problem

The first step in designing an algorithmic decision-making system is defining the problem that the system needs to solve. This involves identifying the outcome that the system should optimize for, as well as any constraints or trade-offs that need to be considered.

For example, a healthcare organization might want to develop an algorithmic system to identify patients who are at high risk for readmission to the hospital. The outcome that the system should optimize for is minimizing readmissions, but there may also be constraints or trade-offs to consider, such as the cost of interventions and the impact on patient outcomes.

Data Collection and Quality

Once the problem has been defined, the next step is to collect and prepare the data needed to train the algorithmic model. This involves identifying relevant data sources, cleaning the data, and ensuring that the data is of sufficient quality to be used in the model.

Data quality is critical for algorithmic decision-making systems, as decisions made by these systems are only as good as the data they are trained on. Organizations need to ensure that their data is accurate, complete, and representative of the population they are serving.

Model Selection and Evaluation

Once the data has been collected and prepared, the next step is to select an appropriate machine learning model to use in the algorithmic system. There are a wide variety of machine learning models to choose from, each with its strengths and weaknesses.

Organizations need to evaluate different models based on factors such as accuracy, interpretability, and scalability, and select the model that best meets their needs.

Once a model has been selected, it needs to be trained on the data and evaluated to ensure that it is performing as expected. This involves using techniques such as cross-validation to test the model's performance on unseen data.

Deployment and Monitoring

Once the algorithmic system has been designed and tested, it can be deployed in the organization. However, deployment is not the end of the process - organizations need to continuously monitor the system's performance to ensure that it is functioning as intended.

Monitoring involves tracking key metrics, such as accuracy and false positive rates, and addressing any issues that arise. Organizations also need to ensure that the system is transparent and explainable so that users can understand how decisions are being made.

The Economic Perspective of AI

According to Rai et al. (2019) artificial intelligence (AI) refers to machines performing the cognitive functions that are associated with humans, such as learning, interacting, problem-solving, and displaying creativity. It is becoming a central force in a society due to its significant spread into the business area (Graβmann and Schermuly, 2020). Advancements in AI are helping companies to move from product-centric models toward digitally enabled business models (Sjödin et al., 2021). The main challenge here is the lack of AI capabilities (Brock and Von Wangenheim, 2019).

AI application can assist providers in creating value closer to the customer's operations based on using data from interconnected equipment to address improvements in the customer's ongoing processes, such as condition based maintenance (Sjödin et al., 2021). According to Iansiti and Lakhami (2020) transformation of operating models is needed to increase the value of AI within the organization.

Lichtenthaler (2020) emphasised the importance of peoples' attitudes toward AI and its effect on their engagement in processes based on digital solutions enabled by AI. People with negative attitude toward AI have strong concerns about data protection and privacy, even when AI adds value to their process.

Over the last few decades, research on artificial intelligence has significantly enhanced the performance of production and service systems (Oke, 2008). Oke (2008) argues that artificial intelligence has become a significant topic of research in practically every industry in the twenty-first century, including engineering, science, education, medical, business, accounting, finance, marketing, economics, the stock market, and law. In addition, Oke (2008) conducts an extensive literature review on the topic of artificial intelligence, providing an overview of the field as well as summarizing the main conclusion from the available literature to the point, including artificial intelligence related topics such as reasoning, genetic algorithm, expert system, understanding of the natural language and knowledge representation. Moreover, Oke (2008) gives a comprehensive overview of advances in the field of artificial intelligence and its applications up to the year of 2008 in general and in the fields of in planning and scheduling, robots, manufacturing, maintenance and environmental pollution. Oke (2008) concludes that farther study is required to push the existing frontier of knowledge in artificial intelligence even further forward by incorporating the ideas and philosophies of certain conventional disciplines into the artificial intelligence frameworks that are already in place, giving the examples which

include designing an artificial intelligence system for a medical issue based on survey data and applying statistical significance, confidence limits, experimental design, and hypothesis testing principles to improve the value of the research and the output of the software designed, among other things.

Martínez and Fernández-Rodríguez (2015) conducted a literature review on the topic of the usage of artificial intelligence as a tool for project success estimation or crucial success factor identification. They conclude that predicting project success or identifying crucial success elements in advance is a subject of research in which researchers have been working diligently for project management goals (Martínez & Fernández-Rodríguez, 2015). Initially, techniques were based on statistical models that were unable to address project management requirements, and researchers in artificial intelligence have discovered algorithms and tools that are more adept at dealing with project uncertainty and the complicated contexts in which projects are often generated (Martínez & Fernández-Rodríguez, 2015). Moreover, Martínez and Fernández-Rodríguez (2015) also conclude that while artificial intelligence technologies are more accurate than conventional methods, they remain complimentary to them, and that artificial intelligence solutions may be quite beneficial for project managers in terms of controlling and monitoring their projects. Nevertheless, they argue that some of the analyzed models contain flaws and limits, indicating that project managers should still employ professional judgment and compare the findings of artificial intelligence to those of traditional tools before making a choice, in order to adapt them as necessary (Martínez & Fernández-Rodríguez, 2015). According to the named literature review, the trend is to combine various artificial intelligence technologies in order to use each tool's strengths while compensating for the deficiencies of the others, and the best results are produced by combining artificial intelligence technologies with project-specific tools such as Continuous Assessment of Project

Performance, which enables real-time analysis, and Project Definition Rating Index, which enables the evaluation of how a project is defined in its very early phases, prior to the start of the project (Martínez & Fernández-Rodríguez, 2015).

Next, de Sousa et al. (2019) conduct a literature review and provide a research agenda on the topic of how an where the artificial intelligence is going within the public sector. They discovered an increasing trend of interest in artificial intelligence in the public sector, with India and the United States being the most active countries (de Sousa et al., 2019). The findings also indicate that general public service, economic affairs, and environmental protection are the government responsibilities that have generated the greatest research on artificial intelligence (de Sousa et al., 2019). De Sousa et al. (2019) report that the

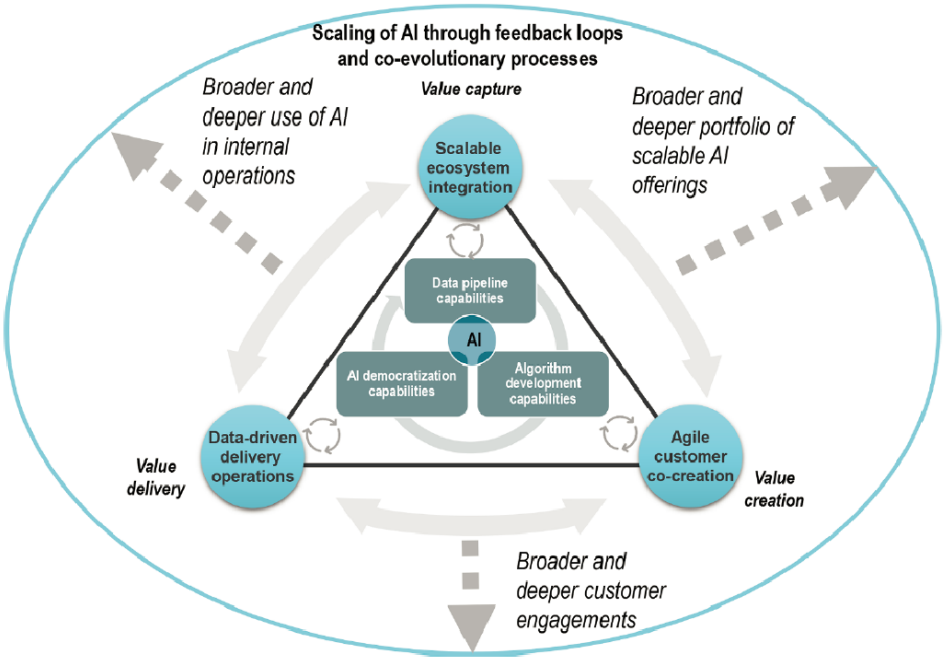
Artificial Neural Networks approach was the most frequently used in the research reviewed and was identified as a technology that produces favorable outcomes in a variety of application areas. This study also offers a research framework for artificial intelligence solutions in the public sector, demonstrating that policies and ethical considerations about the use of artificial intelligence pervade all layers of application and that solutions may add value to government tasks (de Sousa et al., 2019).

Another extensive literature review on the topic of artificial intelligence is conducted by Di Vaio et al. (2020), who aim to review and analyze the literature on the role of artificial intelligence in the development of long-term business models, thus providing a quantitative review of the academic literature that is the basis of the field's development. The study addresses the links between artificial intelligence, fast breakthroughs in machine learning, and long-term sustainability, and aims specifically to determine whether this branch of computer science can influence production and consumption patterns in order to achieve sustainable resource management in accordance with the Sustainable Development Goals outlined in the United Nations 2030 Agenda for Development (Di Vaio et al., 2020). Furthermore, named literature review conducted by Di Vaio et al. (2020) seeks to draw attention to the role of Knowledge Management Systems in the cultural shift toward the widespread adoption of artificial intelligence for sustainable business models. As indicated by the authors, the main contributions of this literature review are: i) a detailed examination of the main underlying link between artificial intelligence and sustainable business models, providing a holistic picture when necessary, ii) identification of a research need addressing Knowledge Management Systems through artificial intelligence and, finally, iii) implications of artificial intelligence for Sustainable Development Goals are highlighted in the article. The academic and managerial implications of Knowledge Management Systems in the sustainable business models are also examined, where the artificial intelligence may serve as a vehicle for meeting the Sustainable Development Goals by enabling for the identification of the cultural change that organizations must through in order to attain sustainable objectives, resulting in conclusion that corporate enterprises, academic researchers, practitioners, and policymakers should work together to advance the application of artificial intelligence in sustainable business models (Di Vaio et al., 2020).

Finally, Borges et al. (2021) argue that, despite the enormous promise of artificial intelligence technologies for solving problems, there are still concerns with practical application and a lack of expertise regarding how to employ artificial intelligence strategically to produce commercial value. In that context, they conduct a study which seeks to close the identified knowledge gap by providing a critical review of the literature on the

integration of artificial intelligence and organizational strategy; synthesizing existing approaches and frameworks, emphasizing potential benefits, challenges, and opportunities; and presenting a discussion of future research directions (Borges et al., 2021). Borges et al. (2021) assessed study papers using a systematic review of the literature and thus offering a conceptual framework which is analyzed in terms of four value creation sources: (i) decision assistance; (ii) customer and staff engagement; (iii) automation; and (iv) innovative goods and services.

To sum up, the AI can drive business model innovation and bring new sources of revenue and competitiveness. Still, there are many challenges and uncertainties on that way that companies must understand and manage.



Framework for scaling AI capabilities through business model innovation

Source: Sjödin et al. (2021:583)

Sjödin et al. (2021) proposed a framework of three interrelated AI capabilities that manufacturing companies must develop for successful digital servitization: data pipeline capabilities, algorithm development capabilities, and AI democratization capabilities. Data pipeline capabilities enable company to explore the industrial environment in a structured way. The quality of input data is the most important for the outcome, and securing this data pipeline is very challenging task. Algorithm development capabilities enable the creation

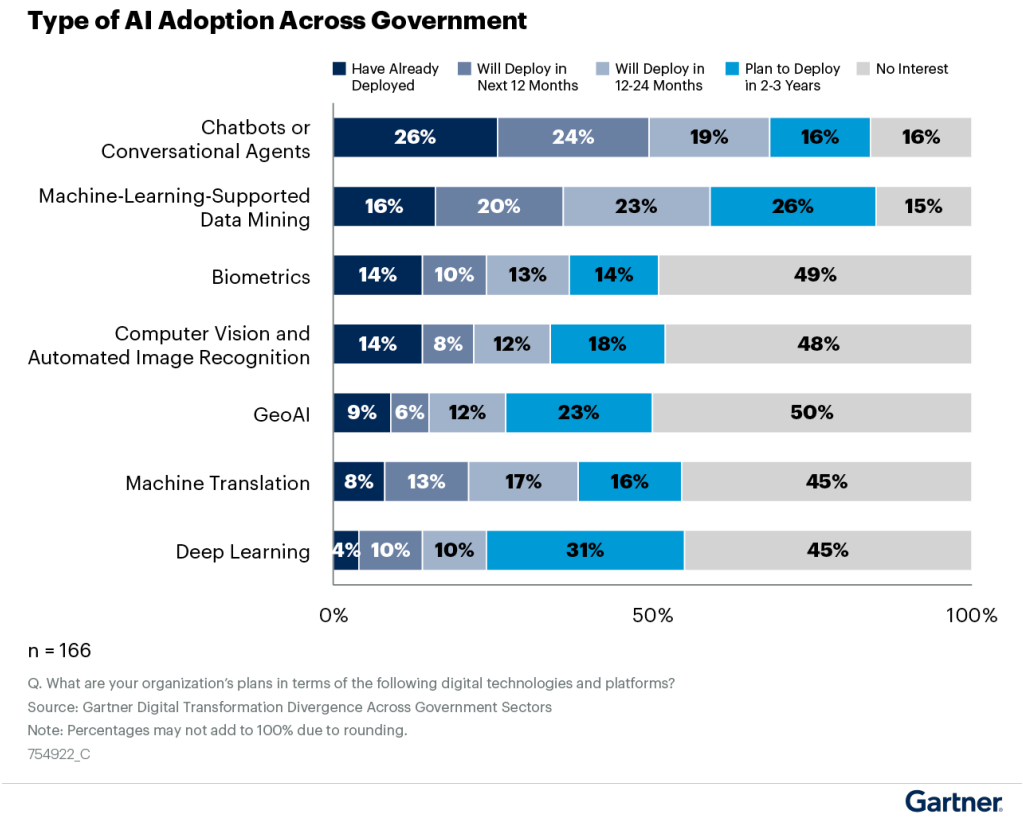
of basic cognitive functions of AI. The algorithms should be able to identify and solve abstract and complex problems. AI democratization capabilities should ensure AI accessibility to the entire organization. All employees should engage in investigating valuable applications of AI. The companies should provide their employees the training in this field so they can participate in AI applications.

Algorithmic Governance Framework

Algorithmic Governance (AG) is a rapidly evolving field that leverages data-driven algorithms to make decisions, manage resources, and solve complex problems. An effective AG framework can be based on four main strategy pillars: invest, experiment, maintain, and divest.

For this framework, we consider 5 key technologies under AG and run them through the four pillars: Artificial Intelligence (AI), Machine Learning (ML), Blockchain, Internet of Things (IoT), RPA

1. **Invest:** The first pillar of the AG framework involves allocating resources to technologies that have proven to be beneficial and have the potential for significant growth.



Source: Gartner, 2021[2]

[2] https://www.gartner.com/en/newsroom/press-releases/2021-10-05-gartner-says-government-organizations-are-increasing-

2. **Experiment:** Once the investment has been made, the next step is experimenting with AG. This involves testing new technologies that have potential but still need to be fully proven or integrated into the business. The experimentation phase is crucial for understanding AG's potential, limitations, and societal impact.

    Invest and Experiment Stages:

    1. **Education**: The New York City Department of Education's use of machine learning to predict students at risk of not graduating on time is an example of an initial investment in AI technology. The system is still in its experimental phase, with educators learning how to utilize the predictions best to provide targeted support to students.

    2. **Health and Social Care**: The UK's National Health Service (NHS) is in the early stages of experimenting with AI to predict which patients will likely miss their appointments. The NHS is investing in this technology to improve patient care and the efficiency of the healthcare system.

    3. **Justice and Legal Affairs**: The UK's Ministry of Justice is investing in AI to predict the outcomes of cases. This is an experimental phase aimed at improving the efficiency of the legal system and informing decision-making.

    4. **Infrastructure and Transportation**: The city of Pittsburgh in the US is initially investing in AI to optimize its traffic light timings. This experiment aims to reduce congestion and improve traffic flow.

3. **Maintain:** Maintaining involves continuing with technologies currently providing value and essential for business operations. After successful experiments, the focus shifts to maintaining and scaling the AG initiatives. This involves monitoring the performance of the AG, continuously improving them, and ensuring they deliver the expected value. It also includes managing risks or challenges.

4. **Divest:** The final pillar of the AG framework is divestment. Not all AG initiatives will deliver the expected results or remain relevant as the organization and its environment evolve. The divestment stage involves identifying such initiatives and strategically withdrawing from them. This could involve reallocating resources to more promising areas or rethinking the approach to AG.

Maintain and Divest Stages:

1. **Public Finance and Social Protection**: The US Internal Revenue Service (IRS) has moved beyond the initial investment and experiment stages by using machine learning algorithms to detect fraudulent tax returns. The IRS is now maintaining this system, which saves the government millions of dollars each year.

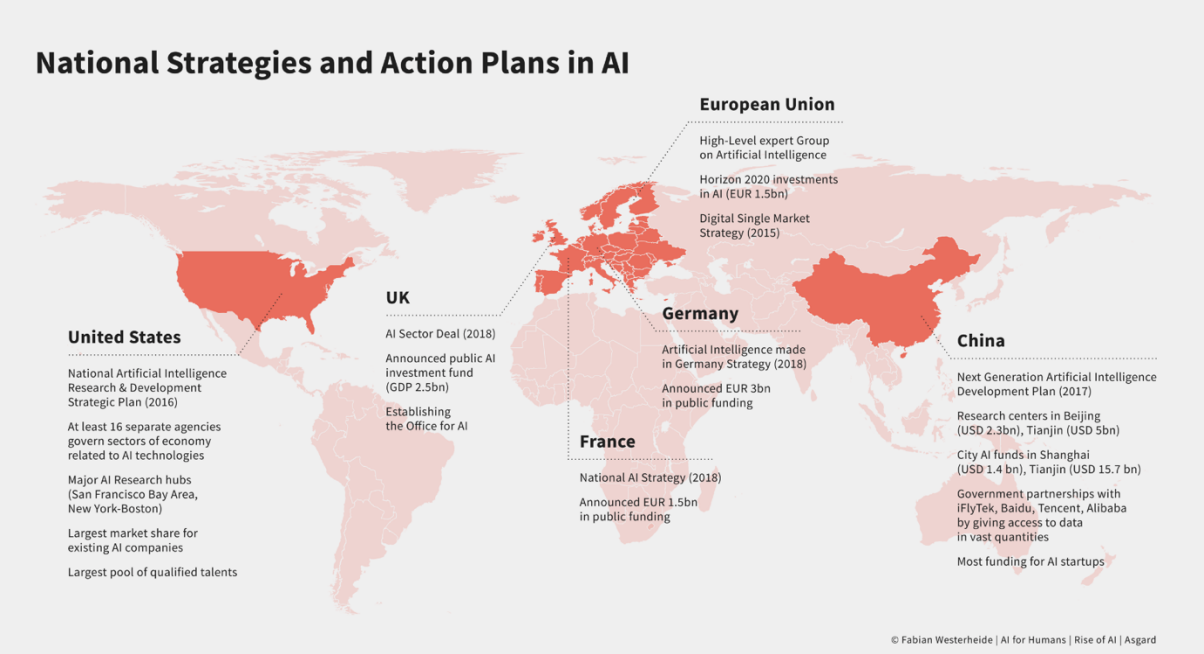
2. **National Defense and Public Safety**: The US Department of Defense is maintaining its use of AI to analyze satellite imagery and detect potential threats. This technology is now crucial to the country's national security infrastructure.

3. **Agriculture, Forestry, and Fishing**: The Australian government's use of AI to predict crop yields and optimize irrigation is an example of a technology that has moved beyond the initial investment stage. The government is now maintaining this system to improve agricultural productivity and sustainability.

4. **Energy and Environment**: Google's use of AI to optimize the cooling of its data centers is an example of a technology that has been scaled up and is now being maintained. This system reduces energy use and carbon emissions.

5. **Culture, Sports, and Tourism**: The city of Paris's use of AI to analyze tourist behavior and optimize its tourism strategy is an example of a technology that has been scaled up and is now being maintained to improve the city's attractiveness as a tourist destination.

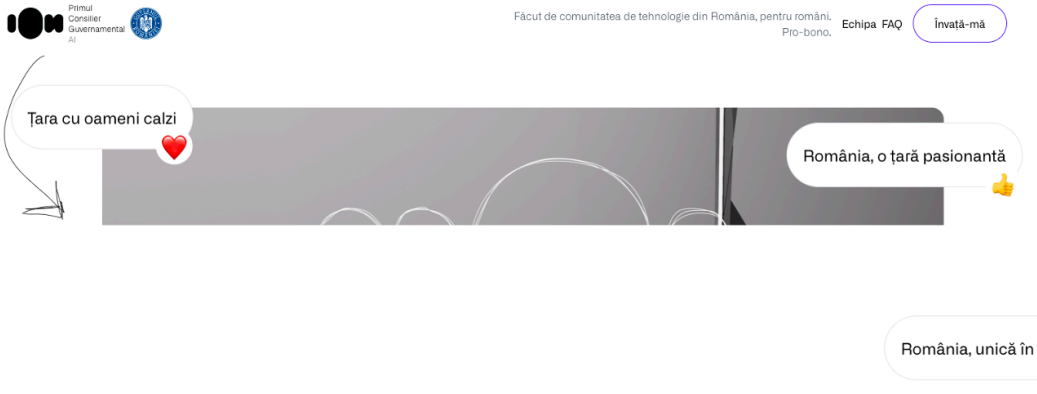
6. **Science, Technology, and Innovation**: The European Organization for Nuclear Research (CERN)'s use of AI to analyze data from its Large Hadron Collider is an example of a technology that has been scaled up and is now being maintained. This system is crucial for driving scientific discovery in particle physics.



Source: Fabian J. G. Westerheide, 2019[3]

In conclusion, the four pillars of invest, experiment, maintain and divest provide a strategic framework for managing the adoption and use of key technologies in Algorithmic Governance. By applying this framework, organizations can effectively navigate AG's complex landscape and harness these technologies' power for improved decision-making and operational efficiency.

[3] https://www.linkedin.com/pulse/artificial-intelligence-industry-global-challenges-westerheide/



In 2021, 1 in 2 Europeans would rather artificial intelligence make decisions instead of politicians

https://ion.gov.ro/

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Work Personas in AG

Algorithmic governance is an emerging field that leverages data-driven algorithms to make decisions, manage resources, and solve complex problems. In the context of work, algorithmic governance can significantly transform the roles and responsibilities of individuals, leading to the emergence of new work personas. These personas represent how individuals interact with, contribute to, and are affected by algorithmic systems.

The Algorithm Designer	The Algorithm Designer is a persona that involves the creation and maintenance of the algorithms that underpin these systems. This role requires a deep understanding of data science, machine learning, and artificial intelligence. Designers must also consider ethical implications, such as fairness and transparency, when creating algorithms. Their work is crucial in ensuring that the algorithms function as intended and do not perpetuate harmful biases.
The Data Curator	The Data Curator is responsible for managing the vast amounts of data that feed into algorithmic systems. This involves collecting, cleaning, and organizing data, as well as ensuring its quality and integrity. The Data Curator must also navigate issues related to privacy and data protection, making sure that data is handled in a way that respects individual rights and complies with relevant regulations.
The Algorithmic Citizen	The Algorithmic Citizen represents the individuals who are affected by algorithmic governance in their work. This can include employees whose performance is evaluated by algorithms, consumers who are targeted by algorithmic marketing, or citizens who are subject to algorithmic decision-making in areas like healthcare or criminal justice. The Algorithmic Citizen must navigate the challenges and opportunities presented by algorithmic governance, such as increased efficiency, potential bias, and the erosion of privacy.
The Algorithm Interpreter	The Algorithm Interpreter is a role that involves making sense of the outputs produced by algorithmic systems. This can include interpreting complex data visualizations, explaining the decisions made by algorithms, or translating algorithmic insights into actionable strategies. This role requires a combination of technical expertise and communication skills, as interpreters must be able to bridge the gap between the algorithmic system and its human users.

In conclusion, the rise of algorithmic governance in the workplace has led to the emergence of new work personas. These work personas are not rigid categories but represent different roles that individuals may play. Depending on the specific context, a single individual may often take on multiple personas. These personas reflect the diverse ways individuals interact with algorithmic systems, highlighting the profound impact of these technologies on our work and lives. As algorithmic governance continues to evolve, understanding and navigating these roles will be crucial.

Skills Map of AG Workers

Algorithmic governance is an emerging field involving algorithms and data science to make decisions and manage systems. As this field grows, so does the need for diverse skills. Here, we present a skills map for algorithmic governance workers, outlining the key competencies required in this innovative and rapidly evolving sector.

Technical Skills

At the core of algorithmic governance is a strong foundation in technical skills. These include:

1. **Data Science and Analytics:** Workers must be proficient in collecting, cleaning, and analyzing large datasets. They should be familiar with statistical analysis and predictive modeling and be able to use data visualization tools to communicate their findings effectively.

2. **Algorithm Development** involves designing and implementing algorithms to process data and make decisions. Workers should have a strong understanding of machine learning and artificial intelligence and be proficient in programming languages such as Python or R.

3. **Systems Thinking:** Algorithmic governance involves managing complex systems. Workers should be able to understand these systems holistically, identifying interconnections and potential impacts of different decisions.

Ethical and Legal Understanding

Algorithmic governance also requires a deep understanding of ethical and legal considerations. This includes:

1. **Ethical Decision-Making:** Algorithms can significantly impact people's lives, and these impacts must be considered and managed ethically. Workers should be able to identify potential ethical issues and make decisions that respect principles such as fairness, transparency, and privacy.

2. **Legal Compliance:** Workers should be familiar with laws and regulations related to data protection, privacy, and algorithmic decision-making. They should be able to ensure that their algorithms comply with these laws and be prepared to adapt to new regulations as they emerge.

Soft Skills

Finally, soft skills are crucial for effective algorithmic governance. These include:

1. **Communication:** Workers should be able to communicate complex technical concepts to non-technical stakeholders and to listen and respond to feedback and concerns.

2. **Problem-Solving:** Algorithmic governance often involves navigating complex and uncertain situations. Workers should be able to think critically, adapt to new challenges, and find innovative solutions to problems.

3. **Collaboration:** Algorithmic governance is often a team effort, requiring collaboration between data scientists, ethicists, legal experts, and other stakeholders. Workers should be able to work effectively in teams, respecting and valuing diverse perspectives.

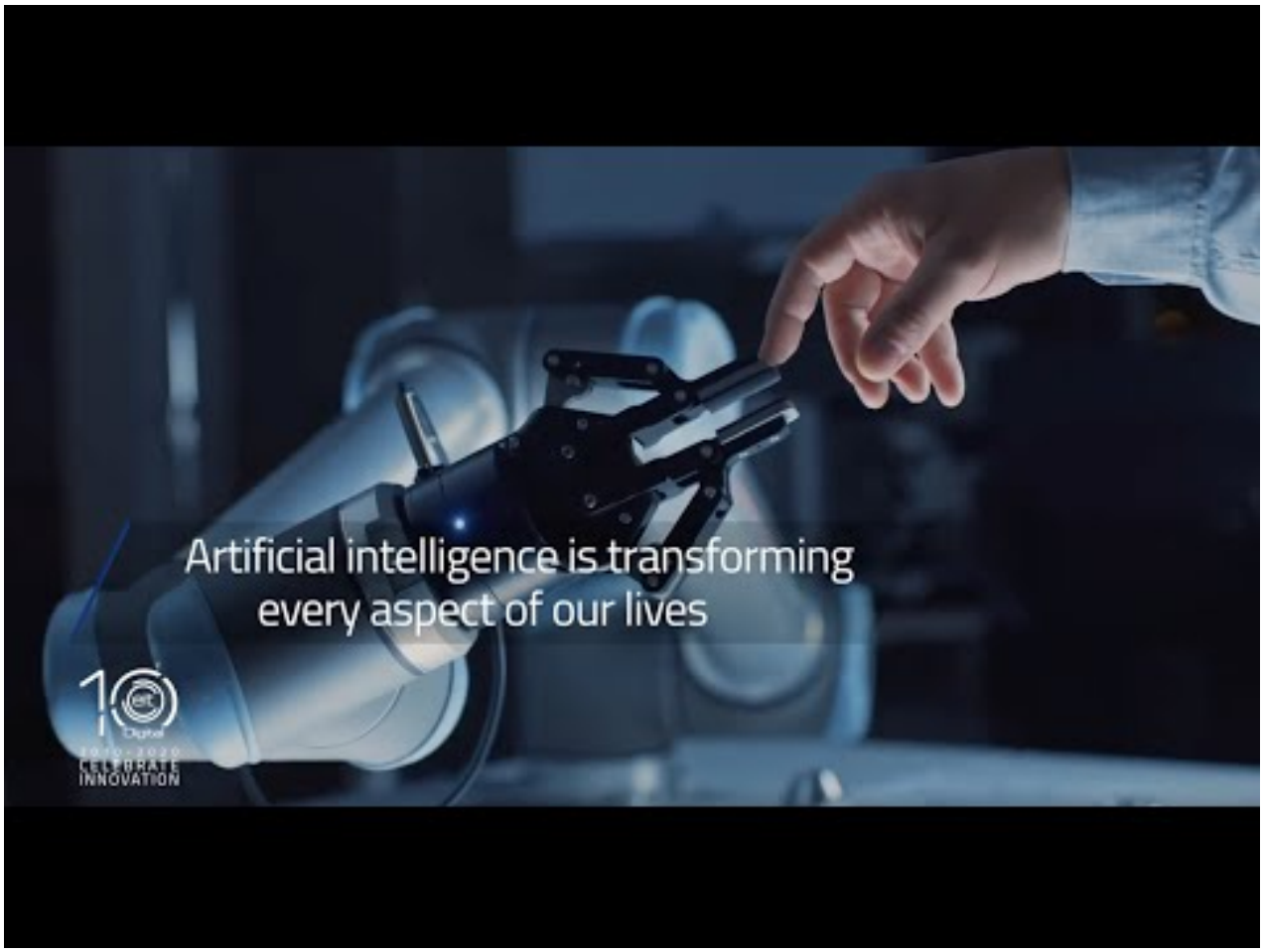
These skills are not exhaustive, and the required skill set can vary depending on the specific role and industry. However, they provide a general guide to highly valued skills in the digital transformation era.

In conclusion, the skills map of an algorithmic governance worker is diverse and multifaceted, encompassing technical skills, ethical and legal understanding, and soft skills. As algorithmic governance continues to evolve, so will the skills required, making continuous learning and adaptability key attributes of successful workers in this field.

Insights on AG from Europe

A European approach to Artificial intelligence

The EU's approach to artificial intelligence centres on excellence and trust, aiming to boost research and industrial capacity and ensure fundamental rights.



A resilient Europe fit for the Digital Decade is one where people and businesses benefit from improvements in industry and day-to-day life generated by artificial intelligence (AI). For example, AI can help to treat diseases and minimise the environmental impact of farming.

However, any AI-generated improvements need to be based on rules that safeguard the functioning of markets and the public sector, and people's safety and fundamental rights. If Europe is to be internationally competitive, it must carry these values to the global stage, and facilitate innovation across the EU.

In line with this vision, the Commission published its AI package proposing new rules and actions aiming to **turn Europe into the global hub for trustworthy AI:**

- Communication on Fostering a European Approach to Artificial Intelligence
- Coordinated Plan with Member States: 2021 update
- Proposal for a Regulation laying down harmonised rules on artificial intelligence (Artificial Intelligence Act)

Member States and the Commission are working together to stay at the forefront of AI through **the twin objectives of excellence and trust.**

In 2018, the Commission and EU Member States took the first step by joining forces through a Coordinated Plan on AI that helped lay the ground for national strategies and policy developments.

The 2021 update of the Coordinated Plan on AI brings strategy into action and is aligned with the Commission's digital and green twin priorities, as well as Europe's response to the coronavirus pandemic.

Fostering AI excellence from the lab to the market, the Coordinated Plan puts forward a vision to accelerate investments in AI, to act on AI strategies for their timely implementation and to align AI policies EU-wide.

As part of these efforts, the Commission plans to set up:

- A Public-Private Partnership on Artificial Intelligence, Data and Robotics to define, implement and invest in a common strategic research innovation and deployment agenda for Europe
- Additional Networks of AI Excellence Centres to foster exchange of knowledge and expertise, develop collaboration with industry and foster diversity and inclusion
- Testing and Experimentation Facilities to experiment and test state-of-the-art technology in real-world environments
- Digital Innovation Hubs, one-stop shops to provide access to technical expertise and experimentation, so that companies can "test before invest"
- An AI-on-demand Platform as a central European toolbox of AI resources (e.g. expertise, algorithms, software frameworks, development tools) needed for industry and public sector uses

will strengthen Europe's potential to compete globally.

The global leadership of Europe in adopting the latest technologies, seizing the benefits and promoting the development of human-centric, sustainable, secure, inclusive and trustworthy artificial intelligence (AI) depends on the ability of the European Union (EU) **to accelerate, act and align AI policy priorities and investments.** This is the **key message and a vision of this 2021 review of the Coordinated Plan.**

The 2018 Coordinated Plan on AI represents a joint commitment by the European Commission and Member States to work together to maximise Europe's potential to compete globally. It laid the ground for cooperation, defined areas for investments and encouraged Member States to develop national strategic visions on AI. The processes and the public debates, in Member States, the EU and globally, triggered by the 2018 Coordinated Plan, indicate that it was an essential first step to define a common direction and objectives for a European policy on AI. As a result of the actions agreed and facilitated by the 2018 Coordinated Plan, most Member States have adopted national AI strategies and started to implement them; investments in AI have increased and the EU was able to mobilise a critical resources pool to support those processes.

The 2021 review of the Coordinated Plan is the next step – it puts forward a concrete set of joint actions for the European Commission and Member States on how to create EU global leadership on trustworthy AI. The proposed key actions reflect the vision that to succeed, the European Commission together with Member States and private actors need to:

- **accelerate** investments in AI technologies to drive resilient economic and social recovery facilitated by the uptake of new digital solutions;
- **act** on AI strategies and programmes by implementing them fully and in a timely manner to ensure that the EU reaps the full benefits of first-mover adopter advantages; and
- **align** AI policy to remove fragmentation and address global challenges.

Accelerate private and public investments leveraging EU funding available, for example, through Digital Europe (DEP), Horizon Europe (HE) programmes and the Recovery and Resilience Facility (RRF). The Commission proposed that the Union invest in AI at least EUR 1 billion per year from Horizon Europe and the Digital Europe programmes under the programming period 2021-2027. This EU-level funding should attract and pool investment to foster collaboration among Member States and maximise impact by joining forces, achieving much more together than with uncoordinated, individual efforts.

The objective is to gradually increase public and private investment in AI to a total of EUR 20 billion per year over the course of this decade. In addition, the RRF provides an unprecedented opportunity to modernise and invest in AI to lead globally in the development and uptake of human-centric, trustworthy, secure and sustainable AI technologies. The EU should not miss this opportunity. This Coordinated Plan puts forward how EU funding, including, DEP, HE and RRF can support joint actions among Member States.

Act on AI strategies and programmes by taking timely and concrete steps supported by funding: from intention to action. The 2018 Coordinated Plan showed that coordination and joint efforts between Member States and the European Commission engaging industry and involving the general public in the development and uptake of AI technologies, can bring significant added value to the EU's economy, environment and societies. This means that strategies, initiatives and programmes yield highest value if ideas for collaboration are well designed, targeted and funded. The EU's experience with digital innovation hubs (DIHs) is one example of this. Both technology and public policies on AI have matured and are ready for wide-scale adoption. Globally, the number of businesses using AI technologies tripled in the last year. Developments in related fields, e.g. robotics and the 'internet of things' (IoT), create new technological frontiers and potential for AI systems. The costs of non-action could be significant. Therefore, to move from intention to action, the 2021 review proposes a set of specific actions with a clearly indicated timeline and possible cooperation and funding mechanisms.

Align AI policy to address global challenges and remove fragmentation: Fragmentation between various EU actions as well as fragmentation between national and EU actions could slow progress in the take-up of AI and fumble the achievement of benefits. For this reason, to align joint actions on AI more closely with the 2020 White Paper on AI, the European Green Deal and the EU measures in response to the COVID-19 pandemic, the review strengthens its proposed actions on environment and health. Among other things, the national strategies underlined the importance of building on and promoting the human-centric, trustworthy, secure, sustainable and inclusive approach to AI. National strategies also underlined the need to develop sector-specific joint actions. Accordingly, the 2021 review takes account of changing technological and policy environments and incorporates insights from the two years of implementation of the Coordinated Plan and the strategies adopted by Member States. This alignment is reflected in the proposed new structure of the Coordinated Plan.

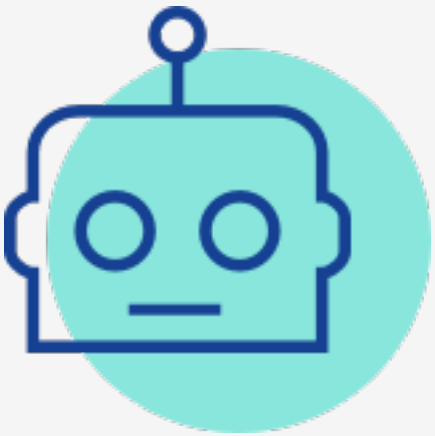
Maximising resources and coordinating investments is a critical component of the Commission's AI strategy. Through the Digital Europe and Horizon Europe programmes, the Commission plans to invest **€1 billion per year in AI**. It will mobilise additional investments from the private sector and the Member States in order to reach an

annual investment volume of **€20 billion** over the course of this decade. And, the newly adopted Recovery and Resilience Facility makes **€134 billion** available for digital. This will be a game-changer, allowing Europe to amplify its ambitions and become a global leader in developing cutting-edge, trustworthy AI.

AI and EU in figures

- **€1 billion**The Commission plan to invest €1 billion per year in AI from its Digital Europe and Horizon Europe programmes.

- **€20 billion**The aim is to attract more than €20 billion of total investment in AI per year in the EU over this decade. The Recovery and Resilience Facility will help speeding up investments and go beyond this aim.



- **> 25%**of all industrial and personal service robots are produced in Europe.

Access to high quality data is an essential factor in building high performance, robust AI systems. Initiatives such as the EU Cybersecurity Strategy, the Digital Services Act and the Digital Markets Act, and the Data Governance Act provide the right infrastructure for building such systems.

A European approach to trust in AI

Fostering trust in AI will create a safe and innovation friendly environment for users, developers and deployers.

Three inter-related legal initiatives proposed by the Commission will help to make Europe a safe and innovation friendly environment for the development of AI.

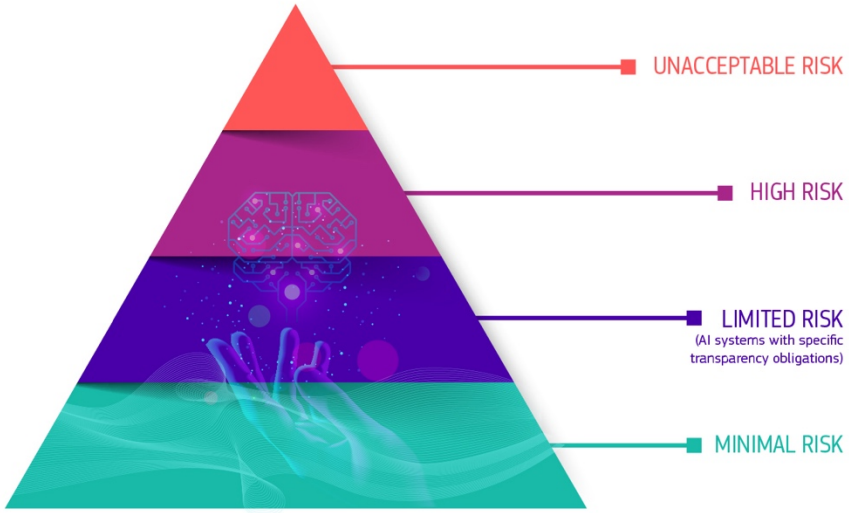
1. European legal framework for AI to address fundamental rights and safety risks specific to the AI systems

2. EU rules to address liability issues related to new technologies, including AI systems (last quarter 2021-first quarter 2022)

3. Revision of sectoral safety legislation (e.g. Machinery Regulation, General Product Safety Directive, second quarter 2021)

The Commission aims to address the risks generated by specific uses of AI through a set of complementary, proportionate and flexible rules. These rules will also provide Europe with a leading role in setting the global gold standard.

The Commission is proposing new rules to make sure that AI systems used in the EU are safe, transparent, ethical, unbiased and under human control. Therefore they are categorised by risk:



Unacceptable

Anything considered a clear threat to EU citizens will be banned: from social scoring by governments to toys using voice assistance that encourages dangerous behaviour of children.

High risk

- Critical infrastructures (e.g. transport), that could put the life and health of citizens at risk
- Educational or vocational training, that may determine the access to education and professional course of someone's life (e.g. scoring of exams)
- Safety components of products (e.g. AI application in robot-assisted surgery)
- Employment, workers management and access to self-employment (e.g. CV sorting software for recruitment procedures)
- Essential private and public services (e.g. credit scoring denying citizens opportunity to obtain a loan)

- Law enforcement that may interfere with people's fundamental rights (e.g. evaluation of the reliability of evidence)
- Migration, asylum and border control management (e.g. verification of authenticity of travel documents)
- Administration of justice and democratic processes (e.g. applying the law to a concrete set of facts)

They will all be carefully assessed before being put on the market and throughout their lifecycle.

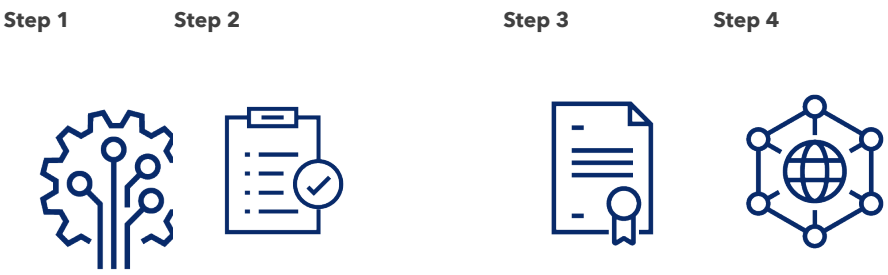
Limited risk

AI systems such as chatbots are subject to minimal transparency obligations, intended to allow those interacting with the content to make informed decisions. The user can then decide to continue or step back from using the application.

Minimal risk

Free use of applications such as AI-enabled video games or spam filters. The vast majority of AI systems falls into this category where the new rules do not intervene as these systems represent only minimal or no risk for citizen's rights or safety.

New rules for providers of high-risk AI systems



Once the AI system is on the market, authorities are in charge of the market surveillance, users ensure human oversight and monitoring, while providers have a post-market monitoring system in place. Providers and users will also report serious incidents and malfunctioning.

Towards trustworthiness: the proposal for a regulatory framework for AI

The use of AI creates a number of **specific high risks for which existing legislation is insufficient.** While there is already a solid framework of legislation in place at EU and national level to protect fundamental rights and ensure safety and consumer rights, including in particular the General Data Protection Regulation and the 'Law Enforcement Directive', certain specific features of AI technologies (e.g. opacity) can make the application and enforcement of such legislation more challenging and generate high risks for which a tailored regulatory response is needed. Therefore, the proposal introduces a set of harmonised rules applicable to the design, development and use of certain high-risk AI systems, as well as restrictions on certain uses of remote biometric identification systems.

By earning people's trust, the envisaged risk-based legislation should foster the uptake of AI across Europe and boost Europe's competitiveness. The Commission's proposal therefore pursues the twin objectives of addressing the risks associated with specific AI applications in a proportionate manner and of promoting the uptake of AI. **To be future-proof and innovation- friendly, the proposed legal framework is designed to**

intervene only where this is strictly needed and in a way that minimises the burden for economic operators, with a light governance structure.

The proposed AI regulation puts forward rules to enhance transparency and minimise risks to safety and fundamental rights before AI systems can be used in the European Union. Its architecture is based on a number of core components which, as a whole, **build a proportionate and risk-based European regulatory approach.**

Firstly, it provides for a technology-neutral definition of AI systems that is **future-proof**, to the extent that it can cover techniques and approaches which are not yet known or developed.

Secondly, to avoid regulatory overreach, the proposal focuses on so-called '**high-risk' AI use** cases, i.e. where the risks that the AI systems pose are particularly high. Whether an AI system is classified as high-risk depends on its intended purpose of the system and on the severity of the possible harm and the probability of its occurrence. High-risk systems include, for example, AI systems intended to be used to recruit people or evaluate their creditworthiness or for judicial decision making. To ensure that the rules are future-proof and can be adjusted to emerging uses and applications of high-risk AI systems, the possibility exists to classify new AI systems as high-risk within certain predefined areas of use.

Thirdly, the proposal provides **that high-risk AI systems need to respect a set of specifically designed requirements,** which include the use of high-quality datasets, the establishment of appropriate documentation to enhance traceability, the sharing of adequate information with the user, the design and implementation of appropriate human oversight measures, and the achievement of the highest standards in terms of robustness, safety, cybersecurity and accuracy. **High-risk AI systems must be assessed for conformity** with these requirements before being placed on the market or put into service. To smoothly integrate with existing legal frameworks the proposal takes account, where relevant, of the sectorial rules for safety, ensuring coherence between the legal acts and simplification for economic operators.

The proposed draft regulation lays down **a ban on a limited set of uses of AI** that contravene European Union values or violate fundamental rights. The prohibition covers AI systems that distort a person's behaviour through subliminal techniques or by exploiting specific vulnerabilities in ways that cause or are likely to cause physical or psychological harm. It also covers general purpose social scoring of AI systems by public authorities.

For the specific case of **remote biometric identification systems** (e.g. facial recognition tools to check passers-by in public spaces), the proposed regulation establishes a stricter approach. The real-time use for law enforcement purposes would in principle be prohibited

in publicly accessible spaces, unless when exceptionally authorised by law. Any authorisation is subject to specific safeguards. In addition, all AI systems intended to be used for remote biometric identification of natural persons must undergo an ex ante conformity assessment procedure by a notified body to check compliance with the requirements for high-risk AI systems, and will be subject to stricter logging and human oversight requirements.

Under the proposed regulation, **other uses of AI systems** are only subject to minimal **transparency requirements**, for example in the case of chatbots, emotion recognition systems or deep fakes. This will allow people to make informed choices or withdraw from a given situation.

Finally, the proposed regulation will encourage the use of **regulatory sandboxes** establishing a controlled environment to test innovative technologies for a limited time, access to Digital Innovation Hubs and access to testing and experimentation facilities, which will help innovative companies, SMEs and start-ups to continue innovating in compliance with the new draft regulation. Further steps on extending the system of sandboxes may be considered as part of the review of the Regulation.

Thus, the proposed regulation on AI combines greater safety and fundamental rights protection while supporting innovation, **enabling trust without preventing innovation.**

EU-funded projects in AI

The EU has already funded a variety of AI projects offering solutions in all areas of society, from agriculture to healthcare, manufacturing, or transport.

Three examples of areas where the use of AI technology has been particularly beneficial are health, environment and in the fight against disinformation.

Neuro-rehabilitation assisting recovery of COVID-19 intensive care patients

The CDAC project, contributed to the development and clinical validation of innovative technologies that have already been used for the rehabilitation of over 3,000 stroke patients across Europe.

More EU-funded projects in the area of health

Smart sensors to help feed growing world population

The ANTARES project is developing smart sensor and big data technologies that could help farmers produce more food in a way that is sustainable for society, farm incomes and the environment.

More EU-funded projects in this area

Online tools for fact-checking and debunking

WeVerify provides verification systems such as plugin that can help fact-checkers, journalists, human rights activists and citizens to debunk and fact-check videos and images online.

More EU-funded projects in the fight against disinformation

Check out also the Annex for more insights into Intelligent Automation , Digital Transformation and Algorithmic Governance in the new Horizon Europe Work Programme - Cluster 4. Digital, Industry and Space.

Innovation in AG: Flexibility, Resilience, and Foresight

Algorithmic governance is an emerging field that leverages advanced computational techniques, including artificial intelligence and machine learning, to enhance decision-making processes in various sectors. This approach to governance is characterized by its flexibility, resilience, and foresight, offering innovative solutions to complex challenges.

The Importance of These Three Elements in AG

1. **Flexibility**: Algorithmic governance is inherently flexible, capable of processing vast amounts of data and adapting to new information in real time. This flexibility allows for dynamic decision-making that responds quickly and efficiently to changing circumstances. For instance, in public policy, algorithms can analyze real-time data from various sources to inform policy adjustments, ensuring that governance measures remain relevant and effective in rapidly changing environments.

2. **Resilience**: Resilience in algorithmic governance refers to the system's ability to withstand shocks and maintain functionality in the face of unexpected events or anomalies. Advanced algorithms can be designed with self-learning and self-correcting capabilities, enabling them to learn from errors or unexpected outcomes and adjust their operations accordingly. This resilience is crucial in maintaining the integrity and reliability of algorithmic governance systems, particularly in critical sectors such as healthcare, finance, and national security.

3. **Foresight**: Foresight is a key feature of algorithmic governance, with predictive analytics playing a central role. By analyzing historical and real-time data, algorithms can identify patterns and trends, predict future scenarios, and inform proactive decision-making. This foresight can be invaluable in various contexts, from anticipating economic trends and informing fiscal policy to predicting disease outbreaks and public health strategies.

In conclusion, innovation in algorithmic governance is marked by flexibility, resilience, and foresight. These characteristics enable more responsive, robust, and forward-looking governance, potentially enhancing decision-making in a wide range of sectors. However, it is crucial to navigate the ethical and legal considerations associated with algorithmic governance carefully, ensuring transparency, accountability, and the protection of individual rights in the age of data-driven decision-making.

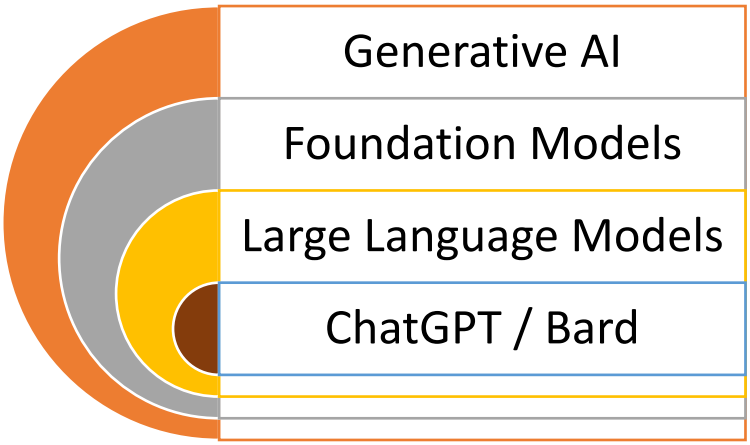
Trends in Algorithmic Governance

In the realm of digital transformation, Algorithmic Governance has emerged as a significant trend. This concept refers to the use of advanced algorithms and data analytics to automate and enhance decision-making processes within organizations. These algorithms, often powered by machine learning and artificial intelligence, can analyze vast amounts of data to identify patterns, predict outcomes, and make recommendations. They are increasingly being used in various sectors, from finance and healthcare to public administration, to improve efficiency, accuracy, and fairness. However, the rise of algorithmic governance also raises important questions about transparency, accountability, and bias. As algorithms become more integral to governance, it is crucial to develop frameworks and standards to ensure they are used responsibly and ethically. This includes measures to prevent algorithmic bias, protect privacy, and ensure that human oversight and intervention remain an essential part of the decision-making process.

Source: Gartner, 2023[4]

[4] https://www.gartner.com/en/articles/gartner-top-10-strategic-technology-trends-for-2023

Focusing on the trends for the next 10 years in 2022 was not reflective of the shifts that occured in 2023 with Generative AI becoming mainstream. By early 2023, the talk of the town was ChatGPT and the potential uses and risks of this technology.



Generative AI is not the only trend evident in 2023.

Source: Gartner, 2023[5]

[5] https://www.gartner.com/en/industries/high-tech/trends/top-trends-for-tech-providers

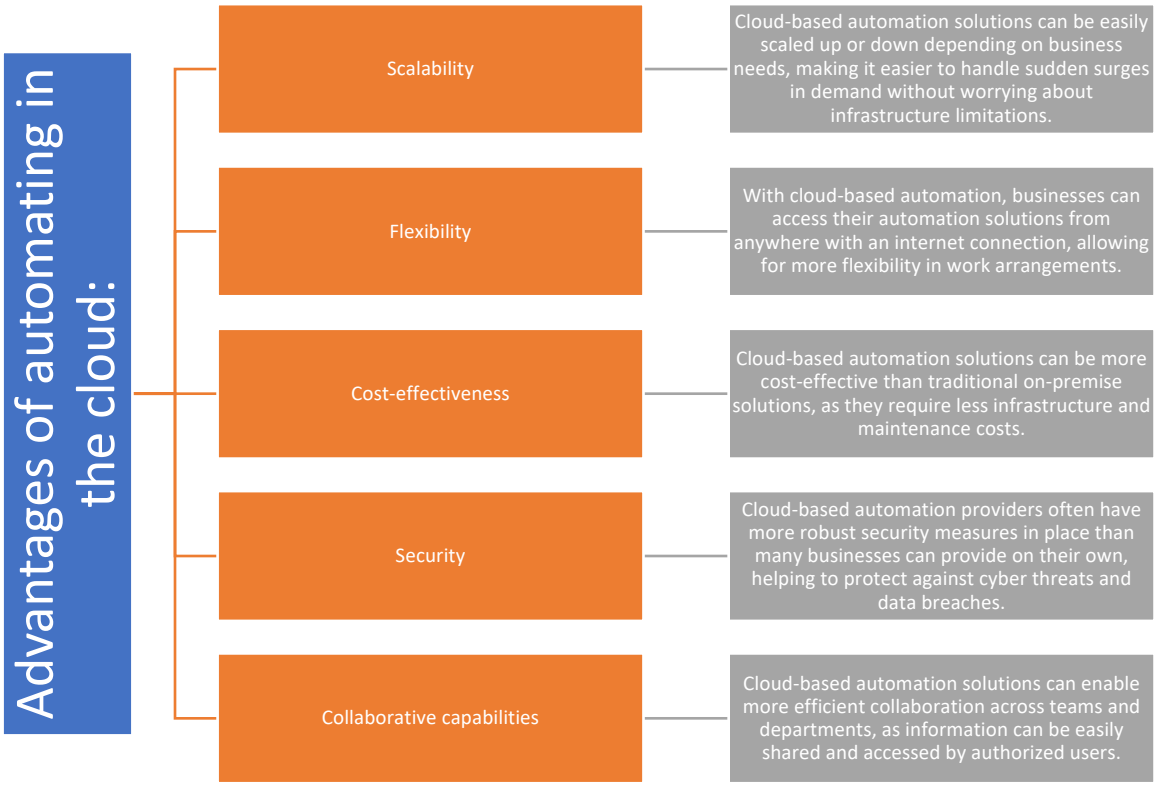
Greater adoption of Robotic Process Automation (RPA)	RPA has been gaining momentum in recent years as businesses seek to automate repetitive tasks and improve efficiency. Finance departments have been early adopters of RPA, using it to automate tasks such as invoice processing and payment reconciliation. Marketing departments can also benefit from RPA by automating tasks such as social media posting and email marketing campaigns. Intelligent Process Automation (IPA)
Intelligent Process Automation (IPA)	IPA is the next evolution of RPA, combining automation with artificial intelligence and machine learning to enable more complex and cognitive tasks..
Increased use of Artificial Intelligence and Machine Learning(AI)	Artificial intelligence and machine learning (ML) have been among the most significant technological advancements in recent years, and their impact is only set to grow in 2023. From chatbots and virtual assistants to autonomous vehicles and predictive analytics, AI and ML are being integrated into an ever-expanding range of applications across industries.
Low-code/No-code Development	Low-code and no-code development is a way for businesses to create applications without requiring traditional coding knowledge. This is achieved through visual interfaces and drag-and-drop tools that allow anyone to create software applications with ease. This trend has been gaining traction in recent years, with the rise of platforms like Monday.com. The benefits of low-code and no-code development are clear. It allows businesses to create custom software applications quickly and easily, without the need for extensive coding knowledge. The growing importance of data management and governance
The growing importance of data management and governance	Effective data management and governance are becoming critical for businesses in all industries, regardless of their size. The increasing use of cloud-based solutions and the growth of big data have resulted in an explosion of data, making it difficult to manage, analyse, and use it effectively. This has made data governance a key concern for businesses. By implementing a comprehensive data management and governance system, businesses can streamline their data management processes and ensure that data is clean, accurate, and consistent across all systems.
Expansion of cloud-based automation solutions	Cloud-based automation solutions are becoming more prevalent as businesses seek to reduce the cost and complexity of on-premises solutions. Marketing departments can benefit from cloud-based automation by using tools such as marketing automation platforms to manage and automate marketing campaigns. For example, a cloud-based marketing automation platform can be used to manage email marketing campaigns, social media posting, and lead scoring. This can reduce the time and effort required to manage these processes, and improve the overall effectiveness of marketing campaigns.
Rise of Hyper-Automation	Hyper-automation is a step further than traditional automation, using advanced technologies like AI, machine learning, and robotic process automation to create ful

Source: SYSCOR, 2023[6]

Another significant trend is the shift toward cloud computing. As noted by Deloitte, businesses are increasingly moving their operations to the cloud to enhance scalability and flexibility. Furthermore, the European Commission and European Parliament have emphasized the importance of data privacy and cybersecurity in

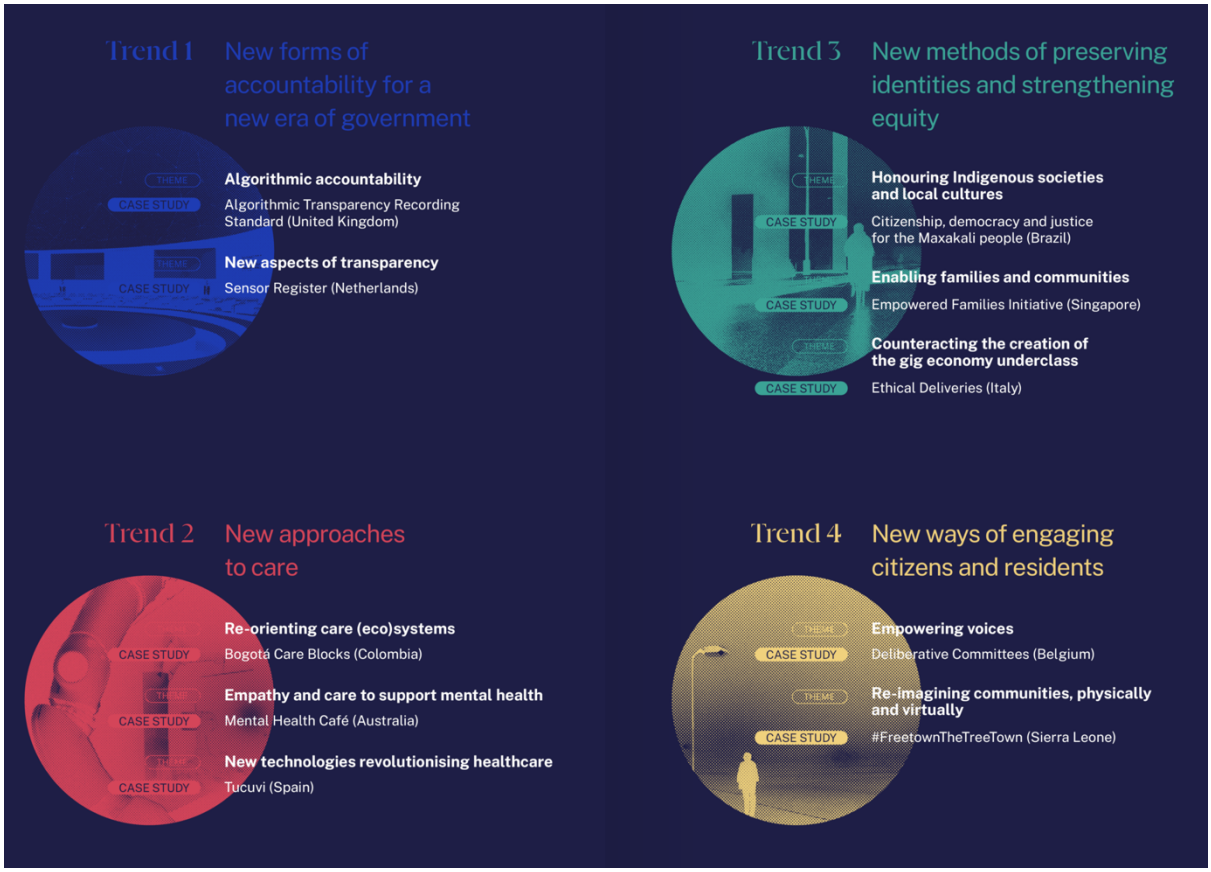
[6] https://syscor.ai/2023/03/14/7-automation-trends-to-look-out-for-in-2023-and-beyond/

digital transformation, with new regulations being implemented to protect consumer data. Lastly, Bearing Point's reports indicate a trend toward customer-centric digital transformation, where businesses leverage digital technologies to improve customer experiences. These trends underscore the evolving nature of digital transformation and its growing impact on business operations.



Source: SYSCOR, 2023[7]

[7] https://syscor.ai/2023/03/14/7-automation-trends-to-look-out-for-in-2023-and-beyond/



Source: OECD - OPSI, 2023[8]

[8] https://oecd-opsi.org/publications/trends-2023/

Conclusion: AG and Public Policy Delivery

Algorithmic governance refers to using computational systems, particularly algorithms, in the decision-making processes of governance. These systems can analyze vast amounts of data, identify patterns, and make predictions or decisions based on the analyzed data. As we delve into the intersection of algorithmic governance and public policy delivery, we must consider the potential benefits and risks.

Public policy can play a significant role in fostering algorithmic governance at both national and European levels. Policies can be designed to encourage the adoption of algorithms in public administration, service delivery, and decision-making processes. For instance, policies could promote algorithms in areas such as traffic management, healthcare delivery, or environmental monitoring, where data-driven decision-making can enhance efficiency and effectiveness.

Public policy can also foster algorithmic governance by establishing a supportive regulatory environment. This could involve creating standards for algorithmic transparency and accountability, funding research and development in algorithmic technologies, or facilitating collaboration between government, academia, and industry in this field.

While algorithmic governance holds promise, it also presents certain risks that public policy must address. One of the primary concerns is the potential for bias in algorithmic decision-making. Algorithms are designed and trained by humans, and they can inadvertently perpetuate existing societal biases if not properly managed. This could lead to unfair outcomes in social services or law enforcement areas.

Another risk is the potential erosion of privacy. The use of algorithms often involves collecting and analyzing large amounts of personal data, which could be misused or mishandled. Public policy must therefore ensure robust data protection measures are in place.

Finally, there is the risk of over-reliance on algorithms in decision-making. Algorithms are tools that can aid human decision-making, but they should only replace human judgment partially. Policies should therefore ensure that there is always a human in the loop, able to review and override algorithmic decisions when necessary.

In conclusion, while public policy can foster algorithmic governance, it must also manage the associated risks. This will require a balanced approach that harnesses the benefits of algorithms while safeguarding against their potential pitfalls.

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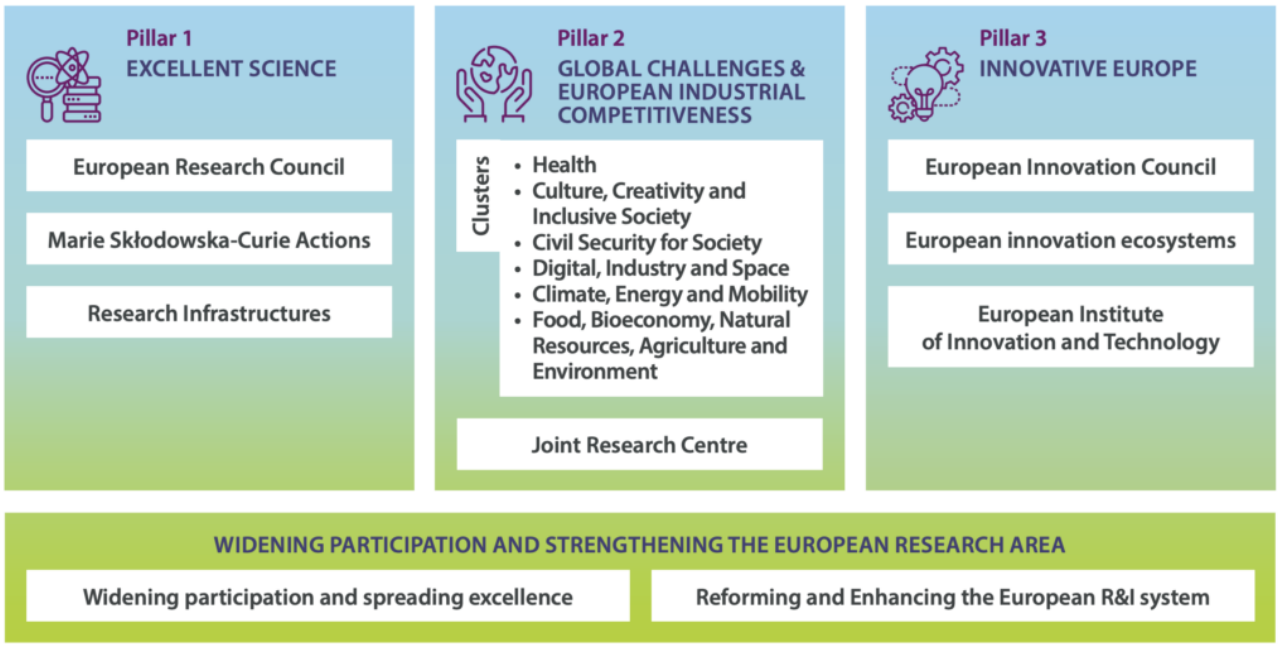
Intelligent Automation , Digital Transformation and Algorithmic Governance in the new Horizon Europe Work Programme - Cluster 4. Digital, Industry and Space

On 15th June 2021, the European Commission adopted the main work programme of Horizon Europe for the period 2021-2022. Horizon Europe is the 95,5 billion euros Research and Innovation programme for 2021-2027. Aligned with the ambitious objectives of the European Green Deal, Horizon Europe will contribute to achieve a more sustainable and digital Europe.

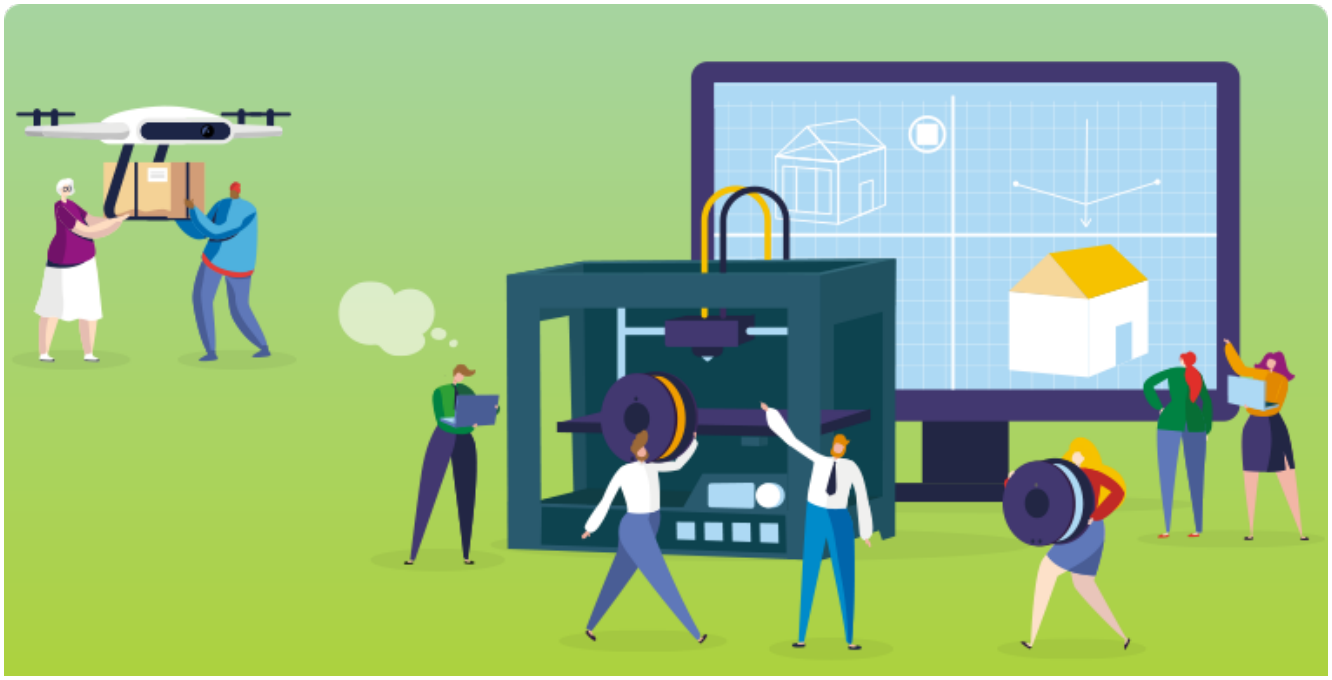
It should be recalled that Horizon Europe has 3 main pillars: Excellent science (Pillar 1), Global challenges and European Industrial Competitiveness (Pillar 2) and Innovative Europe (Pillar 3).

Pillar 2 is composed of 6 clusters:

- Health
- Culture, Creativity and Inclusive Society
- Civil Security for Society
- Digital, Industry and Space
- Climate, Energy and Mobility
- Food, Bioeconomy, Natural resources, Agriculture and Environment



Under the Pillar 2, ***Cluster 4 "Digital, Industry and Space***" focuses more specifically on the EU approach to technology development and aims to deliver in 6 objectives, through a series of **"destinations" (technology sectors)** in the Work Programme:



Destination's title	*Budget for 2021- 2022*	
1	Climate neutral, circular and digitised production	€734M
2	Increased autonomy in key strategic value chains for resilient industry	€760M
3	World leading data and computing technologies	€349M
4	Digital and emerging technologies for competitiveness and fit for the Green Deal	€734M
5	Open strategic autonomy in developing, deploying and using global space-based infrastructures, services, applications and data	€497M

6	A human-centred and ethical development of digital and industrial technologies	€328M

DESTINATION 1– CLIMATE NEUTRAL, CIRCULAR AND DIGITISED PRODUCTION

In the first Work Programme, outcomes of R&I investments in the long-term will focus on the following impacts:

- Accelerate the **twin green and digital transition of the manufacturing and construction sectors**;
- Create a **new green, flexible and digital way to build and produce goods**. This will lead to sustainable, flexible, responsive and resilient factories and value chains, enabled by digitisation, AI, data sharing, advanced robotics and modularity. At the same time it will help reduce CO_2 emissions and waste in these sectors, and enhance the durability, reparability and re-cycling of products/components. It will also ensure better and more efficient use of construction-generated data to sustain competitiveness and greening of the sector;
- **Make the jobs of the humans working in the manufacturing and construction sectors more attractive and safer**, and point the way to opportunities for upskilling;
- Set out a credible pathway to contributing to **climate neutral, circular and digitalised energy intensive industries**;
- **Increase productivity, innovation capacity, resilience, sustainability and global competitiveness of European energy intensive industries**. This includes as many as possible new large hubs for circularity by 2025 (TRL 7 or above); developing sustainable ways for circular utilisation of waste streams and CO_2/CO streams; and electrifying industry to enable and foster a switch to a renewable energy system;
- Contribute to a substantial reduction of waste and CO_2 emissions, turning them into alternative feedstocks to replace fossil-based raw materials and decrease reliance on imports.

In line with the European Green Deal objectives, research and innovation activities should comply with the 'do **no significant harm' principle**. Compliance needs to be assessed

both for activities carried out during the course of the project as well as the expected life cycle impact of the innovation at a commercialisation stage (where relevant). The robustness of the compliance must be customised to the envisaged TRL of the project. In this regard, the potential harm of Innovation Actions contributing to the European Green Deal will be monitored throughout the project duration.

Business cases and exploitation strategies for industrialisation: This section applies only to those topics in this Destination, for which proposals should demonstrate the expected impact by including a *business case and exploitation strategy for industrialisation*.

The *business case* should demonstrate the expected impact of the proposal in terms of enhanced market opportunities for the participants and enhanced manufacturing capacities in the EU, in the short to medium term. It should describe the targeted market(s); estimated market size in the EU and globally; user and customer needs; and demonstrate that the solutions will match the market and user needs in a cost-effective manner; and describe the expected market position and competitive advantage.

The *exploitation strategy* should identify obstacles, requirements and necessary actions involved in reaching higher TRLs, for example: matching value chains, enhancing product robustness; securing industrial integrators; and user acceptance.
For TRLs 7-8, a credible strategy to achieve future full-scale manufacturing in the EU is expected, indicating the commitments of the industrial partners after the end of the project. Activities beyond R&I investments will be needed to realise the expected impacts: these include the further development of skills and competencies (also via the European Institute of Innovation and Technology, in particular EIT Manufacturing); and the use of financial products under the InvestEU Fund for further commercialisation of R&I outcomes.

DESTINATION 2 – INCREASED AUTONOMY IN KEY STRATEGIC VALUE CHAINS FOR RESILIENT INDUSTRY

In the first Work Programme, topics under Destination 2 **'Increased autonomy in key strategic value chains for resilient industry**' will tackle missing segments in strategic areas and value chains, to strengthen the EU's industrial base and boost its competitiveness and open strategic autonomy. In addition, it will explore how increased circularity has the potential to increase the open strategic autonomy of EU industry through the more efficient use of resources and secondary raw materials.

This will be achieved through R&I activities focusing on four areas key for the resilience of EU industry:

- *Raw materials:* The EU is highly dependent on a few third countries for the (critical) raw materials it needs for strategic value chains (including e-mobility, batteries, renewable energies, pharmaceuticals, aerospace, dual-use and digital applications). In a context where demand is set to increase , these will remain, more than ever, a vital prerequisite for both Europe's open strategic autonomy and a successful transition to a climate- neutral and circular economy. Responding to the Critical Raw Materials action plan R&I activities will tackle the vulnerabilities in the entire EU raw materials value chain, from sustainable and responsible exploration, extraction, processing, recycling, contributing to building the EU knowledge base of primary and secondary raw materials and ensuring secure, sustainable and responsible access to (critical) raw materials.
- *Advanced materials* that are sustainable by design are needed to meet the challenges of climate neutrality, transition to a circular economy and a zero-pollution Europe, as well as broader benefits in many different applications. While chemical and related materials production is expected to double globally by 2030, this will largely take place outside Europe. To overcome its reliance on imports of basic chemicals and related materials, Europe needs to strengthen its capacity to produce and use chemicals in a sustainable and competitive way. In addition, it is necessary to continue work on an ecosystem, based on open innovation test beds (OITBs), which enables the rapid development, uptake and commercialisation of advanced materials. All actions should be guided by sustainable-by-design principles, i.e. environmental and health safety, circularity and functionality.
- *Circular value chains:* to complement the circular technologies in Destination 1, further technological and non-technological elements (such as business models and the traceability of products) are necessary in the transition to novel low-emission and circular industrial value chains.
- *Preparedness of businesses/smes/startups:* European companies, and in particular SMEs, have shown a chronic lagging behind the US and China in the uptake of new, and especially digital, technologies.

DESTINATION 3– WORLD LEADING DATA AND COMPUTING TECHNOLOGIES

Europe's lead in the data economy also increasingly depends on its capability to autonomously develop key High Performance Computing (HPC) technologies, provide access to world-class supercomputing and data infrastructures, maintain global leadership in HPC applications, and foster the acquisition of HPC skills. This is the purpose of the activities funded by the EuroHPC Joint Undertaking.

Investments in this Destination contribute substantially to climate change objectives. Energy efficiency is a key design principle in actions, which will lead to new technologies and solutions that are cornerstones for a sustainable economy and society. These solutions

range from environmentally sustainable data operations to balancing loads among centralised clouds and distributed edge computing, from decentralised energy sources to energy-harvesting sensors/devices, etc.

Finally, a robust data ecosystem rests as much on the wide, practical availability of top solutions and results, as on the transparency of the research and innovation process. To ensure trustworthiness and wide adoption by user communities for the benefit of society, actions should promote high standards of transparency and openness. Actions should ensure that the processes and outcomes of research and innovation align with the needs, values and expectations of society, in line with Responsible Research and Innovation.

This Destination is structured into the following headings, which group topics together with similar outcomes to address a common challenge:

- **Data sharing in the common European data space**

Data sharing and data interoperability are still at their infancy; few data markets for sharing industrial data exist. In a recent survey, more than 40% of the SMEs interviewed claim they had problems in acquiring data from other companies. The diffusion of platforms for data sharing and the availability of interoperable datasets is one of the key success factors which may help to drive the European data economy and industrial transformation. On the other hand, Europe is developing a strong legal framework for data and is well positioned to exploit data from the public sector. The potential of European industrial data (from digitising industry) creates great synergies to feed European data ecosystems with industrial, personal, and public sector data, to be shared and exploited in full compliance with the ethical and legal framework.

In line with the FAIR principles (Findable, Accessible, Interoperable and Reusable), the overall objective of the topics in this heading is to make Europe the most successful area in the world in terms of data sharing and data re-use while respecting the legal framework relating to security and privacy and fostering collaboration and building on existing initiatives.

- **Strengthening Europe's data analytics capacity**

Recent developments in sensor networks, cyber-physical systems, and the ubiquity of the Internet of Things (IoT) and Artificial Intelligence (AI) have increased the collection of data (including health care, social media, smart communities, industry, manufacturing, education, construction, agriculture, water management finance/insurance, tourism, education, and more) to an enormous scale (by 2025, 463 exabytes of data will be produced every day in the world). There is significant potential for advances of data

analytics at the intersection of many scientific, technology and societal fields (e.g. data mining, AI, complex systems, network science, statistics, natural language understanding, mathematics, particle physics, astronomy, earth observation...), and new methods and approaches are needed along the whole data life- cycle and value chain.

The overall objective of the topics in this heading is to make the EU fully autonomous in processing, combining, modelling and analysing such large amounts of data for efficiently predicting future courses of action with high accuracy and advanced decision-making strategies. The use of natural resources is reduced and waste avoided by making it possible to replace classical experiments by data-driven digital models. The technological achievements under this heading will support the development of responsible and useful AI solutions, built on high-quality and high-value data.

• From Cloud to Edge to IoT for European Data

Today, 80% of the processing and analysis of data takes place in data centres and centralised computing facilities, and 20% in smart connected objects; only 1 European company in 4 use cloud technologies; 75% of the European cloud market is dominated by non-EU players. Considering the pace of development in this area outside of the EU, the implementation of the activities will require R&I instruments with great flexibility, including the support of SMEs and start-ups, to nurture a European ecosystem and deliver swift results.

In line with Europe's data, green and industrial strategies, for capitalising on the paradigm shift to the edge, Europe needs to pool major investments. Focus must be on the development and deployment of the next generation computing components, systems and platforms that enable this transition to a compute continuum with strong capacities at the edge and far edge in an energy efficient and trustworthy manner.

The overall objective of the topics in this heading is to establish the European supply and value chains in cloud to edge computing to Internet of Things (IoT) and tactile internet by integrating relevant elements of computing, connectivity, IoT, AI cybersecurity. New cloud/edge technologies with enhanced performance enabled by AI will increase European autonomy in the data economy required to support future hyper-distributed applications.

Finally, actions on high-end computing for exascale performance and beyond will be entirely implemented in the Joint Undertaking EuroHPC.

Today, Europe critically depends on foreign High Performance Computing (HPC) technologies that are essential for scientific and industrial innovation and competitiveness.

By 2022 the next generation supercomputers will reach exascale performance, none of them with European technology components.

The overall objective such actions is to ensure digital autonomy for Europe in key high-end supercomputing technology (hardware and software) and applications, and developing the first exascale supercomputer based predominantly on European technology by 2026.

DESTINATION 4 – DIGITAL AND EMERGING TECHNOLOGIES FOR COMPETITIVENESS AND FIT FOR THE GREEN DEAL

Despite a strong European scientific community's on AI and robotics, Europe lags behind in AI diffusion. Actions under this Destination will develop world-class technologies serving the needs of all types of European industries (e.g. manufacturing, healthcare, transport, agriculture, energy, construction), providing top-performing solutions that businesses will trust and adopt to maintain their competitiveness and maximise their contribution to environmental sustainability.

While Europe is strong in many sectors, it must take ownership of its unavoidable future transformations for competitiveness, prosperity and sustainability, by early leadership in new and emerging enabling technologies, e.g. alternative computing models such as bio- and neuro-morphic approaches, use of biological elements as part of technology, and sustainable smart materials. In particular, the far-reaching impact of quantum and graphene technologies on our economy and society cannot be fully estimated yet, but they will be disruptive for many fields. Actions in this Destination will ensure that Europe stays ahead in this global race and is in a position to achieve game-changing breakthroughs.

In line with the vision set out in the Digital Decade Communication (COM(2021)118), in particular its 'secure and performant sustainable digital infrastructures' pillar, actions under this Destination will support Europe's open strategic autonomy, and reinforce and regain European industry's leaderships across the digital supply chain. It will direct investments to activities that will ensure a robust European industrial and technology presence in all key parts of a greener digital supply chain, from low-power components to advanced systems, future networks, new data technologies and platforms. Autonomy will require sustaining first- mover advantage in strategic areas like quantum computing and graphene, and investing early in emerging enabling technologies.

Investments in this Destination contribute substantially to climate change objectives. Energy efficiency is a key design principle in actions, which will lead to new technologies and solutions that are cornerstones for a sustainable economy and society. These solutions range from ultra-low-power processors to AI, Data and Robotics solutions for resource optimisation and reduction of energy consumption and CO2 emissions; from highly

efficient optical networking technologies and ultra-low-energy 6G communication networks to robotics that overcome the limitation of energy autonomy. Furthermore, promising emerging avenues are addressed via ultra-low power operations enabled by spintronics and 2D materials-based devices and systems for energy storage and harvesting.

Actions should devote particular attention to openness of the solutions and results, and transparency of the research and innovation process. To ensure trustworthiness and wide adoption by user communities for the benefit of society, actions should promote high standards of transparency and openness. Actions should ensure that the processes and outcomes of research and innovation align with the needs, values and expectations of society, in line with Responsible Research and Innovation.

As a result, this Destination is structured into the following headings, which group topics together with similar outcomes to address a common challenge:

• Ultra-low power processors

Today Europe is not highly present in the microprocessor market. The objective of this heading is to ensure EU open strategic autonomy through the development of low-power, low environmental impact, secure and trusted components and software for strategic value-chains.

Proposals are invited under the topics of this heading in this work programme and under the topics of the 'Key Digital Technologies' Joint Undertaking addressing the electronics value chain (including software technologies).

• European Innovation Leadership in Electronics

Europe currently has a leading position in key digital technologies for the strategic sectors of automotive, industrial manufacturing, aerospace, defence and security and healthcare. In the emerging area of post-Moore components, there is a number of promising technological approaches with no established players or dominant regions.

The objective of this heading is to secure access in Europe to cutting-edge digital technologies, to strengthen current leadership in strategic value-chains, and to seize emerging opportunities addressing existing technological gaps.

Proposals are invited under the topics of this heading in this work programme and under the topics of the 'Key Digital Technologies' Joint Undertaking addressing the electronics value chain (including software technologies).

• European Innovation Leadership in Photonics

The European photonics industry has an excellent position in core segments, far above the average EU market share. The objective of the topics grouped in this heading is to strengthen current leadership in photonic technologies and applications, and to secure access in Europe to cutting-edge photonic technologies.

The topics of this heading are under the co-programmed Partnership 'Photonics'. • 6G and foundational connectivity technologies

Today European suppliers of connectivity systems are well placed with around 40% of global 5G market share, but with high competitive pressure from Asian and US players. In terms of technology, first 5G standards are available since end of 2017 enabling Gigabit/s speeds and ~millisecond latencies. Trusted industrial services based on 5G technology are at very early stage.

The objective of this heading is to develop a strong supply chain for connectivity, increase European competitiveness and autonomy in Internet infrastructures, and to contribute to a reduction of the growing global energy consumption of the Internet and of the industry vertical users of the Internet, and to other key SDG's such as affordability and accessibility to infrastructures. The topics under this work programme address in particular the need to develop micro electronic components and systems supporting future disaggregated Radio

Access Networks and components enabling the advent of all optical networks for ultra low consumption and ultra high security networks.

Proposals are invited under the topics of this heading in this work programme and under the topics of the 'Smart Networks and Services" Joint Undertaking addressing the future connectivity platforms including edge cloud and IoT technologies.

• Innovation in AI, Data and Robotics

Europe has an outstanding track record in key areas of AI research, Europe's scientific community is leading in AI and robotics, but substantial efforts are needed to transform this into (disruptive) European AI technology products that can withstand international competitors. Europe also lags behind in technology diffusion, less than half of European firms have adopted AI technology, with a majority of those still in the pilot stage. 70% of these adopter companies, only capture 10% of full potential use, and only 2% percent of European firms in healthcare are using those technologies at 80% of potential. Moreover, as demonstrated during the COVID-19 crisis, many AI, Data and Robotics solutions exist today but only a limited number of them reaches the level of maturity and adoption necessary to solve the problems at hand. Therefore, there is room for improved adoption by industry, which requires a drastic increase of industry-driven R&I, from basic research to

large-scale piloting. In general, industry acknowledges the potential of AI technologies, but often lacks demonstrable benefits for their particular use cases.

The objective of this heading is to ensure autonomy for Europe in AI, data and robotics in developing world-class technologies serving the needs of all types of European industries, from manufacturing to healthcare, public sector, utilities, retail, finance, insurance, transport, agriculture, energy, telecommunications, environmental monitoring, construction, media, creative and cultural industries, fashion, tourism, etc. providing top-performing solutions that industries will trust and adopt to maintain their competitiveness and maximise their contribution to environmental and resources sustainability.

Several topics of this heading are under the co-programmed Partnership 'AI, Data and Robotics'.

• Tomorrow's deployable Robots: efficient, robust, safe, adaptive and trusted

Europe is leading in robotics industry, with a high intensity of use of robots. Europe is also scientifically leading in robotics' cognition, safety, manipulation, soft robotics, underwater and aerial robotics, with demonstrated impacts in many use-cases in key industrial sectors (e.g.: healthcare, agri-food, forestry, inspection and maintenance, logistics, construction,

manufacturing, etc.) and across multiple modalities (aerial, marine, ground, in-vivo and space).

The objective of this heading is to ensure autonomy for Europe in robotics, leading the way in research, development and deployment of world-class technologies.

Several topics of this heading are under the co-programmed Partnership 'AI, Data and Robotics'.

• European leadership in Emerging Enabling Technologies

Europe's leading industry sectors have a solid track-record in constant improvement, but less so for embracing transformative ideas. The pathway from research to industry uptake is often long and staged, with no intertwining of research and industry agendas. In the age of deep- tech, though, this intertwining is essential.

The objective of this heading is to identify early technologies that have the potential to become Europe's future leading technologies in all areas of this cluster and to establish industry leadership in these technologies from the outset. This heading has a unique focus on off-roadmap transformations with a longer time-horizon but profound potential impact.

• Flagship on Quantum Technologies: a Paradigm Shift

Since 2018, the Quantum Technologies Flagship has been consolidating and expanding Europe's scientific leadership and excellence in quantum, in order to foster the development of a competitive quantum industrial and research ecosystem in Europe. The EU's aims for quantum R&I in the next decade are set out in detail in the Quantum Flagship's Strategic Research Agenda (SRA) and its associated main Key Performance Indicators, which drafted and published in 2020 on quantum computing, quantum simulation, quantum communication, and quantum sensing and metrology. Projects in each of these areas are currently supported by the Flagship, by other EU research initiatives and by national programmes.

The objective of this heading is to further develop quantum technologies and their applications in the areas of quantum computing, simulation, sensing and communication, in order to strengthen European technological sovereignty in this strategic field and achieve first-mover industry leadership, capitalising on Europe's established excellence in quantum science and technology maintaining and developing quantum competences and skills available in the EU and raising the capabilities of all Member States in this field.

The aim of the Commission's Digital Decade strategy is for the EU to become digitally sovereign in an interconnected world, and in the coming years quantum technologies will be a key element of this digital sovereignty, as they are of global strategic importance. Quantum technologies will be also used, among others, for sensitive applications in the area of security, and in dual-use applications. Other world regions are already investing heavily in all areas of

quantum technologies research. In this context, the EU must take action to build on its strengths, and to carefully assess and address any strategic weaknesses, vulnerabilities and high-risk dependencies which put at risk the attainment of its ambitions. This will enable it to safeguard its strategic assets, interests, autonomy and security, while advancing towards its goal of open strategic autonomy.

The Quantum Technologies Flagship conducts research and development activities in the key domains of quantum computing and simulation, quantum communication, and quantum sensing. The Flagship will contribute to world-leading quantum computers and simulators, that will be acquired by the European High Performance Computing Joint Undertaking, and will be crucial to achieving its Digital Decade goal of having its first computer with quantum acceleration by 2025, with a view to being at the cutting edge of quantum capabilities by 2030. These machines will have a profound impact, with applications in medicine, manufacturing, or new material and new drugs design but also in cryptography, finance and many other sensitive domains.

Moreover, the Flagship's research into quantum communication will support the development of a European quantum communication infrastructure (EuroQCI). This key component of the EU Cybersecurity Strategy will provide an extremely secure form of encryption to shield the EU's government data and critical infrastructures against cyber-attacks. Ensuring that the latest quantum communication technologies remain accessible in the EU is crucial to maintaining European security in the face of future threats.

Research in quantum sensing technologies is also vital to the EU's interests, as it will develop European expertise in quantum clocks for navigation (including for embarkation on Galileo satellites) and precise timing applications, sensors for autonomous vehicles, and the next generation of medical sensors.

It is therefore clearly in the EU's interests to protect European research in these domains, the intellectual property that it generates, and the strategic assets that will be developed as a result, while taking steps to avoid situations of technological dependency on non-EU sources (in line with the call of the October 2020 European Council to reduce Europe's strategic dependencies). With this in mind, the Commission has decided that, in the research areas covered by 12 actions in this work programme in quantum computing and simulation, communication, and sensing, only Associated Countries that meet certain conditions will be eligible to participate in these actions.

- **Graphene: Europe in the lead**

The starting point is the Graphene Flagship, launched in 2013, which already reached European leadership in graphene and related 2D materials. The work is now coming to a critical point where first simple products are being launched. R&I activities would now need to be pursued and accelerated in order to translate achieved technology advances that are at TRL 3-5 into concrete innovation opportunities and into production capabilities in many industrial sectors (e.g. aviation, automotive, electronics, batteries, healthcare).

The objective of this heading is to strengthen and accelerate the technology developments that support a strong European supply and value chain in graphene and related materials and provide first-mover market advantages of scale.

DESTINATION 5 – OPEN STRATEGIC AUTONOMY IN DEVELOPING, DEPLOYING AND USING GLOBAL SPACE-BASED INFRASTRUCTURES, SERVICES, APPLICATIONS AND DATA

Today EU citizens enjoy watching satellite TV, increasingly accurate global navigation services for all transport modes and users (e.g. mobile phones and car navigation systems), extended Earth monitoring for land, marine, atmosphere and climate change, global

meteorological observation and accurate cartographies of a wide number of variables. Space also makes important contributions to security crisis management and emergency services. These are key assets for the EU policies on climate, environment, transport, agriculture and secure society (e.g. Maritime Strategy, the Arctic Strategy, the Digital Agenda, the Common Security and Defence Policy, the Sustainable Development Strategy, the SGDGs). Finally, the space sector is a source of economic growth, jobs and exports.

This Destination is therefore structured along the following headings:
1 Foster competitiveness of space systems
2 Reinforce EU capacity to access to space
3 Evolution of Space and ground infrastructures for Galileo/EGNOS
4 Evolution of services: Copernicus
5 Development of applications for Galileo, EGNOS and Copernicus
6 Innovative space capabilities: SSA, GOVSATCOM, Quantum
7 Space entrepreneurship ecosystems (incl. New Space and start-ups) and skills

DESTINATION 6 – A HUMAN-CENTRED AND ETHICAL DEVELOPMENT OF DIGITAL AND INDUSTRIAL TECHNOLOGIES

As Europe takes the lead in the green and digital transitions, workers, regions, and societies are faced with extremely fast transformations, and will be differently affected by these changes. The rapid adoption of new technologies offers an immense potential for improved standards of living, safer mobility, better healthcare, new jobs, or the personalisation of public services. At the same time, it presents risks such as skills mismatches, digital divides, customer lock-in, or serious breaches of security or privacy.

As Europe sets off on its path to recovery towards a greener, digital and more resilient economy and society, the need to improve and adapt skills, knowledge and competences becomes all the more important. Developments in digital and enabling technologies have the potential to enhance social inclusion, can inform up-skilling training programmes and ensure a two-way engagement with society with regard to developing technologies.

The issue of trust has become central in the use of technologies, following revelations about the exploitation of personal data, large-scale cybersecurity and data breaches, and growing

awareness of online disinformation. As outlined in the White Paper on Artificial Intelligence (COM(2020)65), for AI technologies, trust requires in particular improving transparency (explainability, expected levels of performance). For the Internet, increasing trust requires new tools and services to ensure that GDPR is a reality for end-users.

It is also an opportunity for Europe to re-gain presence on the consumer electronics market, by developing new interactive applications in various sectors with solutions meeting European values and requirements in terms of privacy and security. The COVID-19 crisis has also shown how important distance and innovative learning is for society.

Actions under this Destination will support EU objectives of inclusiveness, by supporting a human-centred approach to technology development that is aligned with European social and ethical values, as well as sustainability. These actions will further contribute to addressing the

challenges faced by European industry and support the creation of sustainable, high-quality jobs by targeting skills mismatches, the need to empower workers, and ethical considerations relating to technological progress.

Actions should devote particular attention to openness of the solutions and results, and transparency of the research process. To ensure trustworthiness, public awareness and support, wide adoption by user communities for the benefit of society, actions should promote the highest standards of transparency and openness. Actions should ensure that the processes and outcomes of research and innovation align with the needs, values and expectations of society, in line with Responsible Research and Innovation.

This Destination is structured into the following headings, which group topics together with similar outcomes to address a common challenge:

• Leadership in AI based on trust

The objective of this heading is to ensure autonomy for Europe in AI, leading the way in research, development and deployment of world-class technologies that are beneficial to humans individually, organisationally and societally, and that adheres to European values, such as the principles reflected in our fundamental rights and environmental sustainability. Technologies need to be developed that industries and citizens will trust, so and that they could be applied in a wide range of applications and industrial sectors. Trustworthy AI is particularly key in applications such as (but not limited to) healthcare or in diverse critical infrastructures such as energy and transportation.

Some topics of this heading are under the co-programmed Partnership 'AI, Data and Robotics'.

- **An Internet of Trust**

The issue of trust in the internet has become central, following revelations about the exploitation of personal data, large-scale cybersecurity and data breaches, and growing awareness of online disinformation. A 2019 survey shows that half of the global internet users are more concerned about their online privacy compared to a year previously. Distrust in the Internet is causing people to change the way they behave online, for example by disclosing less personal information. Users also express an increasing level of distrust of social media platforms.

The objective of this heading is to develop a trustworthy digital environment, built on a more resilient, sustainable, and decentralised internet, to empower end-users with more control over their data and their digital identity, and to enable new social and business models respecting European values.

- **eXtended Reality (XR)**

Due to its low presence in the consumer electronics industry, Europe is increasingly dependent on external providers in this area. This raises concerns about its digital sovereignty in crucial domains such as digital interaction services that are being adopted by a growing number of European users and industries. The COVID-19 crisis has shown how important distance and innovative learning is for society, our children, their parents and their teachers, maintaining social and educational links under challenging circumstances. Emerging technologies such as virtual reality, eXtended Reality or immersive environments provide numerous opportunities for personalised, innovative, efficient and inclusive learning, for learners of all ages, gender and condition

The objective of this heading is to gain industrial leadership in eXtended Reality technologies and immersive environments, while ensuring the European values of privacy, ethics and inclusiveness. It also aims to support the digital transformation of education through these technologies in particular.

- **Systemic approaches to make the most of the technologies within society and industry.**

This heading promotes various systemic approaches to encourage creativity and make the most of the technologies developed elsewhere within society and industry. They include testing ideas in local communities; support for IP, standardisation and industry-academia exchanges; art-driven design; and assessments of complex socio-economic systems. These are complemented by support for a network of National Contact Points (NCPs), with a special emphasis on engaging with new actors.

Some digital EU funded projects that are shaping our world

Bringing extended reality into sharper focus

EXTEND

Engineers, designers, surgeons and pilots don't yet use extended reality (XR) widely. Finnish company Varjo says this is partly because our eyes can see a hundred times more detail than a normal headset provides. Using the EU-funded EXTEND project as a springboard, Varjo has created high-res XR headsets that seamlessly blend the real and virtual worlds, opening up XR to professional users.

A workforce fit for the factory of the future

FIT4FoF

Future factory workers will need to be good at working together, adapting to rapid change, speaking multiple languages – and doing all this past traditional retirement age. That's quite a challenge for Europe, so the FIT4FoF project set out to help. Central is the idea that workers who understand the challenges ahead can plan, develop and deliver the right training to boost their skills.

Facing up to the social effects of technology

TECHNEQUALITY

The digital divide cuts deep. New technology is changing what people need to succeed in work and society, and traditional predictors of social mobility may be less reliable. The TECHNEQUALITY project is taking a wider view of the issue than simply which jobs will be replaced by machines. A deep understanding of how technology is changing society will help us make the best of the challenges ahead.