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ANNEXES

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Fostering a European approach to Artificial Intelligence

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COORDINATED PLAN ON ARTIFICIAL INTELLIGENCE 2021 REVIEW

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Coordinated Plan on Artificial Intelligence 2021 Review[1]

INTRODUCTION: CREATING EU GLOBAL LEADERSHIP IN HUMAN-CENTRIC AI WITH MEMBER STATES

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**[2]. 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[3]. 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[4].

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)*[5]. 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

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1 European Commission Communication *Coordinated Plan on Artificial Intelligence* (COM(2018) 795 final).

2 The European approach to AI, including the values on the basis of which the EU aims to advance the development and uptake of AI, is set out in the European Commission's *Communication on AI for Europe* (COM(2018) 237 final) and *White Paper on artificial intelligence – A European approach to excellence and trust* (COM(2020) 65 final).

3 Declaration of Cooperation on Artificial Intelligence, signed by all Member States and Norway, April 2018.

4 Each chapter of this document starts with a concise overview of the actions and programming documents adopted at EU level following the adoption of the 2018 Coordinated Plan.

5 There are also other EU funding instruments such as Cohesion Policy programmes that could benefit from the development and uptake of AI technologies. The Commission stands ready to provide technical support to Member States in order to help them review and update national strategies, through the Technical Support Instrument. See Regulation (EU) 2021/240 of the European Parliament and of the Council of 10 February 2021 establishing a Technical Support Instrument (OJ L 57, 18.2.2021, p. 1).

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[6]. 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.[7] Globally, the number of businesses using AI technologies tripled in the last year[8]. 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[9]. 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**[10], 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

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6 RRF is the largest stimulus package ever financed through the EU budget. It will provide Member States with frontloaded financial support in the form of an unprecedented EUR 672,5 billion of loans and grants for the crucial initial years of the recovery, and 20 % of this funding is proposed for 'digital target'. The 'digital expenditure target', corresponding up to EUR 134 billion in the lifecycle of the RRF, could be a game changer in boosting investments, e.g. to build data, cloud, and computing infrastructures, to further research excellence, to support innovation, testing and experimentation, and to increase its use by the public administration and by businesses.

7 E.g. in natural language processing (one of the most rapidly advancing fields of AI), the largest models have grown by a factor of more than 1 500 (the number of parameters went from 100 million in 2018 to 175 billion in 2020; stateof.ai 2020) Advances in AI technologies affect the whole digital supply chain. New components (e.g. improved graphics processing units and neuromorphic chips), new computing concepts (edge and data-driven computing), new data infrastructure and new applications are being developed and coming onto the market.

8 Globally, the number of businesses using AI had grown by 270 % in the previous 4 years and tripled in just the past year. Gartner, *Gartner survey shows 37 per cent of organisations have implemented AI in some form*, 2019.

9 See, e.g. European Parliamentary Research Service, *Europe's two trillion euro dividend: Mapping the cost of non-Europe, 2019-24*. A recent European added value assessment European framework on ethical aspects of artificial intelligence, robotics and AI suggests that a common EU framework on ethics in AI alone (as compared with individual actions by Member States) has the potential to generate EUR 294,9 billion in additional GDP and 4,6 million additional jobs by 2030 (Evas, T, European Parliamentary Research Service, 2020).

10 *White Paper on artificial intelligence – A European approach to excellence and trust* (COM(2020) 65 final).

underlined the need to develop sector-specific joint actions[11]. 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[12].

In order to accelerate, act and align to seize opportunities of AI technologies and to facilitate the European approach to AI, that is human-centric, trustworthy, secure, sustainable and inclusive AI, in full respect of our core European values, this review of the Coordinated Plan puts forward four key sets of proposals for the European Union and the Member States:

Set enabling conditions for AI development and uptake in the EU

- Acquire, pool and share policy insights (Chapter 1)
- Tap into the potential of data (Chapter 2)
- Foster critical computing capacity (Chapter 3)

Make the EU the place where excellence thrives from the lab to the market

- Collaborate with stakeholders through, e.g. the European Partnership on AI, Data and Robotics and expert groups (Chapter 4)
- Build and mobilise research capacities (Chapter 5)
- Provide an environment for developers to test and experiment (TEFs), and for SMEs and public administrations to take up AI (EDIH) (Chapter 6)
- Support the funding and scaling of innovative AI ideas and solutions (Chapter 7)

Ensure that AI works for people and is a force for good in society

- Nurture talent and improve the supply of skills necessary to enable a thriving AI eco-system (Chapter 8)
- Develop a policy framework to ensure trust in AI systems (Chapter 9)
- Promote the EU vision on sustainable and trustworthy AI in the world (Chapter 7)

Build strategic leadership in high-impact sectors

- Bring AI into play for climate and environment (Chapter 11)
- Use the next generation of AI to improve health (Chapter 12)
- Maintain Europe's lead: Strategy for Robotics in the world of AI (Chapter 13)
- Make the public sector a trailblazer for using AI (Chapter 14)
- Apply AI to law enforcement, migration and asylum (Chapter 15)
- Make mobility safer and less polluting through AI (Chapter 16)
- Support AI for sustainable agriculture (Chapter 17)

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[11] AI technologies increasingly impact all economic sectors. This 2021 review of the Coordinated Plan proposes six policy areas for focused joint actions. The selection of policy areas is based on the analysis of the national AI strategies, bilateral consultations, suggestions from Member States and available evidence on AI uptake and market developments. Further revisions of the Coordinated Plan will consider the need to add further areas for joint actions, if necessary.

[12] The Commission had committed to propose to the Member States a revision of the Coordinated Plan in the 2020 White Paper on Artificial Intelligence(COM(2020) 65 final) and in the 2018 Coordinated Plan on Artificial Intelligence (COM(2018) 795 final).

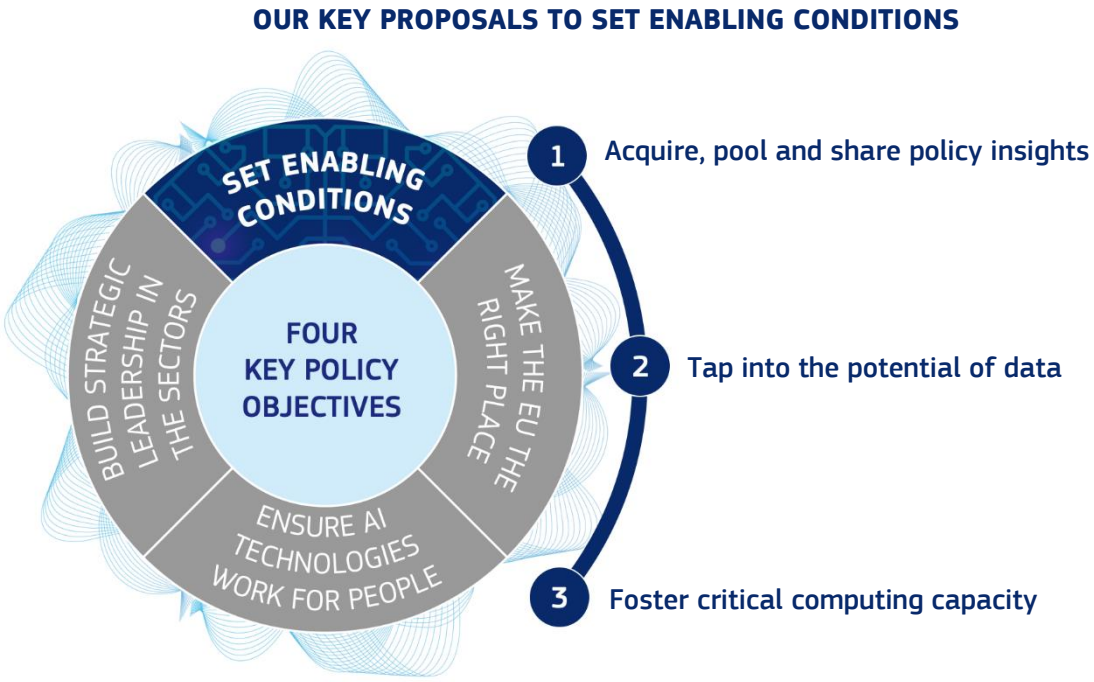
In line with the above, the 2021 review of the Coordinated Plan provides ***an overview of actions taken*** since the adoption of the 2018 Coordinated Plan and sets out ***an outlook*** with concrete proposals and recommendations for further action, identifying areas where the partnership between the EU and the Member States is particularly effective in making Europe a hub for the development and use of cutting-edge, human-centric AI. The 2021 review aims to advance the objectives above and proposes 14 interrelated, joint action areas for collaboration between the European Commission and the Member States (seven horizontal and seven sectoral areas)[13]. As in the EU 2020 White Paper and the 2018 Coordinated Plan, the 2021 review of the Coordinated Plan does not address the development and use of AI for military purposes.

I. SET ENABLING CONDITIONS FOR AI DEVELOPMENT AND UPTAKE IN THE EU

In order to support the development and take-up of AI and to achieve the objectives of this Coordinated Plan, a number of enabling conditions are necessary. The first one is an appropriate **governance and coordination framework.** An efficient and functioning governance and coordination framework can help to build economies of scale, minimise information and transaction costs and facilitate synergies among Member States. The second enabling condition is **data**. The development of AI technologies often requires large, high-quality, secure and robust datasets. It is therefore important to ensure that data can 'flow' within the EU, with our trading partners and across sectors, in line with the EU acquis, including the General Data Protection Regulation for personal data and the Union's international commitments. Third is a **computation infrastructure**. This infrastructure is necessary for storing, analysing and processing the increasingly large volumes of data. In turn, this requires new developments and approaches to increase computing capabilities, e.g. through semiconductors that enable AI algorithms to store, run, and test data. Together, these three factors create broad enabling conditions for AI technologies to succeed in the EU.

Accordingly, to set enabling conditions for AI development and take-up and enhance cooperation among Member States and among Member States and the European Commission, the review proposes to focus on three key actions: to build a governance framework to effectively acquire, accumulate and share policy insights on AI; to tap into the potential of data to unleash its full potential; to foster critical computation infrastructure to support capacity building and enhance the development of AI.

[13] All actions must comply fully with the EU rules on competition law and notably State aid.



1. Acquire, pool and share policy insights

Knowledge is key. Sharing knowledge and policy insights, and coordinating policy actions and investments in a rapidly developing area such as AI can add an important competitive advantage. For this reason, in the 2018 Coordinated Plan the Member States and the Commission agreed on a governance mechanism for joint work and proposed two sets of actions to build policy insights and develop synergies. Member States were encouraged to put into place **national AI strategies** or programmes (or add an AI dimension to other relevant national strategies and programmes) and share these with each other and the Commission[14]; and the Commission pledged to **monitor developments and mobilise expertise**.

1.1. *Maximise the advantages from national strategies and accelerate the proposed actions*

Overview of actions taken

All Member States made substantial efforts to develop national strategies on AI or to include an AI dimension in their existing strategies and programmes[15]. The adoption of national strategies facilitated structured reflection on the priorities and objectives for the development and uptake of AI, and triggered wider public debate in many Member States. The exchange of information on the national strategies also fed into a structured dialogue between the Member States and the Commission.

As the analysis of national strategies indicates, the adoption of national strategies was an important first step to facilitate and streamline European effort on AI. This process helped to identify the priority sectors for joint actions, provided a solid mapping of the main investment priorities planned by the Member States and indicated possible steps forward for common multi-country projects and joint activities.

Outlook

The next step is to ensure that the efforts invested by Member States in developing the

[14] This encouragement was also included in the February 2019 Council Conclusions; (Council of the European Union, *Conclusions on the coordinated plan on artificial intelligence*, 6177/19, 11 February 2019).

[15] See Appendix 1 to this document and JRC's forthcoming AI Watch report on AI national strategies (2021).

national strategies bring concrete results and lead to synergies at EU level. In order to support Member States in their work to develop and implement national strategies on AI, **the Commission will** continue to:

- **facilitate the uptake of and synergies between national actions** identified in the national AI strategies and joint actions under the Coordinated Plan. This may include measures to strengthen coordination mechanisms and provide analysis and studies, for example through AI Watch[16];
- enhance the **provision of information to Member States on the practical means, including funding, to support the development and uptake of AI**. For example, in 2021 the Commission will continue to inform Member States on the EU funding available for AI.

Member States are strongly encouraged to:

- **make best use of relevant EU funding possibilities, including RRF,** to support and reinforce development and uptake of AI technologies at both national and local levels, on the basis of the national strategies, including by crowding in private investment;
- **review and update national AI strategies** as necessary to ensure that identified actions and investments are fully realised in practice and inform the Commission about the progress accordingly[17];
- develop and promote **instruments** that allow **regular monitoring, coordination, evaluation and exchange of experience** and best practice across a broad spectrum of stakeholders;
- **reinforce support for and investment in joint actions** identified in the Coordinated Plan; and
- **share, develop and implement actions on national/regional level that proved to be successful in other Member States**, for example, successful national initiatives to develop and promote a virtual warehouse of data.

1.2. Reap the full benefit of the technical expertise of expert groups on AI facilitated by the European Commission

Technological and socioeconomic developments relating to AI are very dynamic and often require specialised expertise. Accordingly, to monitor the advancement and uptake of AI technologies and facilitate evidence-based policy on AI, the Commission has put considerable effort into mobilising expertise, collecting data, monitoring developments and collecting and analysing stakeholder opinions related to AI.

Overview of actions taken

In order to mobilise expertise[18] related to AI technologies, the Commission established three horizontal expert groups[19]:

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16 See next section 'overview of actions taken' immediately below for the description of AI Watch.

17 Technical support to Member States in order to help them review and update national strategies is available through the Technical Support Instrument, as provided in the Regulation (EU) 2021/240.

18 See also the action area two on PPPs and excellence in research.

19 This section covers main actions. The Commission has also organised numerous technical workshops on AI with experts from various stakeholder groups. Results from the workshops were further discussed at an online conference on the ecosystems of excellence and trust in October 2020, for example.

- **High-Level Expert Group on Artificial Intelligence**[20] – this group extensively analysed the ethical implications of AI for policymaking and produced three deliverables during its mandate:
  - ethics guidelines for trustworthy AI[21];
  - policy and investment recommendations for trustworthy AI[22]; and
  - an assessment list for trustworthy AI (ALTAI)[23].
- **High-Level Expert Group on the Impact of the Digital Transformation on EU Labour Markets** – in 2019, this group issued a report with recommendations, including short-, medium- and long-term policy actions for the EU, Member States, businesses and other stakeholders to shape the digital transformation of the world of work and make it smooth, inclusive and human-centric[24].
- **Expert Group on Liability and New Technologies** – in 2019, this group published a report on *Liability for artificial intelligence and other emerging digital technologies*[25].

In addition to horizontal groups, sectoral expert groups focused on specific policy areas affected by the application of AI technologies including **autonomous vehicles**[26], **aviation**[27], **mobility and transport**[28], **home affairs**[29] and **emerging security risks**[30]. This work provided valuable expertise and contributed to ongoing EU-level policy discussions on AI issues, including the challenges and opportunities that AI technologies bring and the public policy responses needed.

In 2018, the Commission (in coordination with the Member States) developed and launched **AI Watch**[31] in order to monitor developments relating to AI technologies. AI Watch monitors industrial, technological and research capacity, AI policy initiatives in the Member States, investments, AI skills, AI developments and uptake and their impact on the economy, society

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20 High-Level Expert Group on Artificial Intelligence information webpage (November 2020).

21 *Ethics guidelines for trustworthy AI* (2019). The Guidelines put forward a set of seven key requirements that AI systems should meet in order to be deemed trustworthy. A specific assessment list aims to help verify the application of each of the key requirements: (1) human agency and oversight; (2) technical robustness and safety; (3) privacy and data governance; (4) transparency; (5) diversity, non-discrimination and fairness; (6) societal and environmental well-being and (7) accountability.

22 *The policy and investment recommendations for trustworthy AI* (2020).

23 In July 2020, after extensive consultation and testing with companies and other stakeholders, the group published *Assessment list for trustworthy artificial intelligence (ALTAI) for self-assessment* (2020). This self-assessment tool translates EU AI principles into a checklist that guides developers and deployers of AI.

24 *Report of the High-Level Expert Group on the Impact of the Digital Transformation on EU Labour Markets* (April 2019).

25 *Liability for artificial intelligence and other emerging digital technologies*, final report (2019).

26 *Ethics of Connected and Automated Vehicles*, independent expert report (June 2020).

27 European Aviation High Level Group on AI.

28 Communication on *Sustainable and Smart Mobility Strategy – putting European transport on track for the future* (COM(2020) 789 final).

29 The expert group on AI in the domain of home affairs (established in 2020) ensures regular dialogue and exchange of views among authorities from Member States and Schengen associated countries.

30 The EU Agency for Cybersecurity (ENISA) multidisciplinary Ad Hoc Expert Group on cybersecurity covered topics related to AI. The AI Cybersecurity Challenges: Threat Landscape for Artificial Intelligence report published in December 2020 emphasised the need to secure AI systems against external cybersecurity risks and misuses and the increasing opportunities to use AI to support cybersecurity. The recent EU cybersecurity strategy for the digital decade (JOIN(2020) 18 final) highlighted that the current threat landscape is compounded by geopolitical tensions over control of powerful and strategic technologies such as AI.

31 AI Watch (run by the Commission's Joint Research Centre (JRC)) has worked in coordination with the Member States; a steering group composed of Member States' representatives was established in 2019, meeting twice a year.

and public services. In the first two years, it published studies to support evidence-based policymaking[32] and to inform the public debate on AI[33].

Also in 2018, to monitor the adoption and use across Europe of emerging and disruptive technologies for the provision of public services, including AI technologies, the Commission created an **innovative public services (IPSO) platform**[34]. Similarly, to monitor the uptake of emerging digital and key enabling technologies (including AI) in industrial development, in 2020, it launched an **advanced technologies for industry** (ATI) project[35]. It also commissioned a **survey on EU firms' use of AI-based technologies**[36].

In 2020, Eurostat started to collect **data on AI uptake** in the EU. The first data set was collected through four proxy indicators related to AI with focus on chatbots, big data analysis with machine learning, big data analysis with natural language processing and service robots.[37]

The major initiative to collect **stakeholders' opinions** on the EU's AI strategy was an open public consultation which followed the publication of the 2020 White Paper on AI and gathered views in three broad areas: actions to build an ecosystem of excellence; options for a regulatory framework for AI; and actions relating to the safety and liability aspects of AI[38]. In addition to their responses to the public consultation, Member States provided feedback on possible changes to the Coordinated Plan and joint action through discussions in the Group on AI and Digitising European Industry[39], and bilateral consultations with the Commission.

To engage more broadly with stakeholders on AI-related topics, the Commission has established an online forum, the **AI Alliance**[40], which provides a platform for around 4 000 stakeholders from all around the world to exchange information, and discuss the technological and societal implications of AI[41]. The Commission organised AI Alliance assemblies in June 2019 and in October 2020[42].

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32 E.g. on the national AI strategies, AI and health, use and impact of AI in public services, monitoring the evolution of AI technologies, the operational definition of AI, AI history timeline and the analysis of the worldwide AI landscape including an interactive indicator dashboard.

33 All AI Watch reports and analyses are publicly available and open for feedback on the AI Watch web portal. For an overview of AI Watch activities see its *2019 activity report*.

34 For more information on the IPSO platform, see the webpage for the action. This platform now lists 43 specific AI use-cases for public services in Europe.

35 The ATI project aims to analyse and systematically monitor the uptake of advanced technologies by industry across the EU. It provides policymakers, industry representatives and academia with: statistical data on the creation and use of advanced technologies; analytical reports on technological trends, sectoral insights and products; analyses of policy measures and policy tools related to the uptake of advanced technologies; analyses of technological trends in competing economies; and access to technology centres and innovation hubs across EU countries.

36 European Commission, *European enterprise survey on the use of technologies based on artificial intelligence*, information webpage (July 2020). The survey is the first EU-wide quantitative overview on the uptake of AI technologies among European businesses. It is an important instrument to monitor the adoption of AI in Member States and further assess the challenges faced by enterprises, for their internal organisation and externally.

37 Eurostat, results published on 21 January 2020, dataset ISOC_EB_AI.

38 European Commission, *Summary report of the findings* (2020), all contributions to the public consultation are available on the dedicated webpage.

39 See section, Strengthen exchanges and collaboration through the Member States' Group on AI and Digitising European Industry, below.

40 This online forum has over 4 000 members representing academia, business and industry, civil society, EU citizens and policymakers. For example, members of the AI Alliance offered detailed feedback for the HLEG ethics guidelines for trustworthy AI.

41 For an overview of the AI Alliance, see European Commission, *The European AI Alliance* (information webpage, 2020).

42 The first AI Alliance assembly brought together 500 members to provide feedback on the Commission's policymaking on AI. The second assembly with over 1 900 participants, discussed the main findings of the

Outlook

In order to mobilise expertise, monitor ongoing developments and collect data on AI **the Commission will continue to**

- **enhance data collection on AI uptake**, – in 2021, Eurostat will launch a full module on AI covering the uptake of seven AI technologies, uses of AI technologies, sourcing and barriers to use[43]. AI Watch will continue to monitor and collect data on uptake of AI technologies, including in the public sector;
- support the work of the AI Alliance, by running the Alliance Platform and **organising annual AI Assemblies** with a broad spectrum of stakeholders to provide a framework for input into EU policymaking on AI; and
- **evaluate developments and gather necessary knowledge** on AI technologies. This may include, if necessary, for example, new expert groups or sectoral initiatives on AI that would provide input to feed into EU policymaking on AI or assist the Commission in evaluating the actions necessary to support Member States' implementation of EU policy and proposed legislation on AI technologies.

In consultation with Member States, the Commission will

- analyse and by 2022 propose **how to reinforce monitoring** of the development, uptake and impact of AI technologies in the EU in the private and public sectors. This will build on the lessons learned from the work of AI Watch and the national AI observatory initiatives. The analysis will also consider how to further reinforce and build synergies and links with existing monitoring mechanisms[44] or forthcoming EU governance structures on AI[45] or international monitoring activities; and
- regularly monitor **the implementation of the Coordinated Plan** to ensure it remains up to date. On the basis of feedback from Member States on the 2021 review and in consultation with other EU institutions and bodies, the Commission will propose in 2022 a timeline, a matrix and a methodology for the next review of the Coordinated Plan.

1.3. Strengthen exchanges and collaboration through the Member States' Group on AI and Digitising European Industry

The action to facilitate cooperation among Member States and between Member States and the Commission is further supported by governance mechanisms that facilitate the exchange of information and help to set the strategic direction for collaboration on AI policy.

Overview of actions taken

The Member States' Group on Artificial Intelligence and Digitising European Industry (MS Group on AI and DEI), assisted on technical matters by a Sherpa group, steered the discussions between Member States and the Commission. It played a key role in developing

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public consultation on the White Paper on AI and future perspectives in building a European approach for excellence and trust. Workshops held during the event covered topics such as biometric identification, AI and liability, requirements for trustworthy AI, AI conformity assessment, standards and high-risk AI applications.

43 The AI module was included in the 2021 questionnaire and the data will be available in January 2022.

44 Such as the Digital Economy and Society Index (DESI) and the 2030 Digital Compass and connected monitoring efforts introduced in the Communication 2030 Digital Compass: the European way for the Digital Decade (March 2021).

45 Proposal for a Regulation of the European Parliament and of the Council laying down harmonized rules on Artificial Intelligence (Artificial Intelligence Act) and amending certain Union Legislative Acts, COM (2021)206.

and revising the Coordinated Plan. The group met regularly[46] and ensured coordination across national ministries and other stakeholders, e.g. in industry, academia and civil society. During the years following the adoption of the 2018 Coordinated Plan, the group has addressed all the main areas it covers, including AI excellence centres, testing and experimentation facilities (TEFs), the legal framework, regulatory sandboxes, data, skills, AI for the Green Deal, AI for health, DIHs and AI in security.

Outlook

In order to facilitate governance mechanisms for cooperation: **the Member States' Group on AI and Digitising European Industry, facilitated by the Commission, will** continue to:

– **steer discussions between Member States and the Commission**[47] – the group will engage in thematic or sectoral deep dives on topics including, for example, standardisation activities, the socioeconomic impact of AI, financing opportunities, measures to support start-ups, support for public-sector AI uptake and procurement, AI and cybersecurity, and AI and mobile connectivity;

The Commission, with the support of Member States, will continue to:

– evaluate the need to establish cooperation and networks at EU level to build EU capabilities; and
– in collaboration with the future co-programmed partnership on AI, Data and Robotics, exchange best practices from Member States on the development, deployment and uptake of AI systems;

Member States are encouraged to:

– facilitate cooperation and create a **system of regional AI networks**[48]; and

– facilitate discussions on setting up national coalitions and facilitate **best practice exchange** among Member States and stakeholders on existing national **AI coalitions**[49] by bringing together public- and private-sector stakeholders, e.g. in joint workshops on thematic areas of common interest. In cooperation with the co-programmed partnership on AI, Data and Robotics, this action will assist cross-border cooperation and draw in more stakeholders.

2. Tap into the potential of data

The availability of high-quality data, among other things, in respect of diversity, non-discrimination, and the possibility to use, combine and re-use data from various sources in a GDPR compliant way are essential prerequisites and a precondition for the development and deployment of certain AI systems[50]. However, data-sharing, especially between companies, has not taken off at sufficient scale, due to a lack of economic incentives, a lack of trust and a lack of legal clarity[51]. Therefore, the 2018 Coordinated Plan suggested the creation of common European data spaces for seamless data-sharing across borders. It also stressed the

46 The group has met biannually. The supporting Sherpa group has met every 2-3 months.

47 As the action areas under the plan advance, the group will complement the horizontal approach with thematic groups and topical/sectoral workshops.

48 See, for example, the German Digital Hub initiative.

49 E.g. Netherlands AI Coalition and Hungarian AI Coalition.

50 Activities related to data under Horizon Europe will be carried out in collaboration with the co-programmed European Partnership on AI, Data and Robotics, see Chapter 4. In particular, a number of topics will cover the research and development of new technologies for data-sharing in the common European data spaces.

51 See, for example, the impact assessment report and support study accompanying the proposal for a Regulation on data governance (November 2020).

importance of developing a pan-European computing infrastructure and cloud services, especially given the international competition for access to data[52].

Overview of actions taken

On 19 February 2020 the Commission adopted a **European strategy for data**[53], which aims at creating a single market for data to ensure Europe's global competitiveness. This entails creating the right incentives for **data-sharing**, establishing practical, fair, non-discriminatory and clear rules on data access and use, in line with European values and rights such as personal data protection, consumer protection and competition rules. It also means making public sector **data more widely available** by opening up high-value data sets and allowing their re-use for innovation.

In June 2020, the Commission published a **report on business-to-government (B2G)** data-sharing[54] from a high-level expert group[55] and containing a set of policy, legal and funding recommendations in order to make B2G data-sharing in the public interest a scalable, responsible and sustainable practice in the EU. The European strategy on data also promotes data-sharing, for example, **business-to-business (B2B)** practices.

Following up on the data strategy, on 25 November 2020, the Commission proposed a new **Data Governance Act**[56]. The proposed regulation includes a number of measures to increase trust in data-sharing, including in B2B practices[57], and in this way aims at making more quality data available for AI applications. It creates new EU rules on neutrality to allow novel data intermediaries to function as trustworthy organisers of data-sharing. It includes measures to facilitate the reuse of certain data held by the public sector. It provides means to make it easier and safer for companies and individuals to voluntarily make their data available for the wider common good under clear conditions. It calls for the creation of a 'European Data Innovation Board' in order to support and advise on cross-sectoral standardisation and interoperability as an essential element to assure availability of high quality data. The Data Governance act may be complemented by sectoral legislation where needed[58].

Outlook

To support actions on data, the Commission will:

– adopt a proposal for a **Data Act**, in order to stimulate the use of privately-held data by government (B2G), address issues related to data access and use in business-to-business settings, in particular non-personal data resulting from objects connected to the internet of things (Q3 2021)[59]; and

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52 In October 2020, to reinforce cooperation and to pool forces to commit to the next-generation cloud, 27 EU Member States signed the 'Declaration building the next generation cloud for businesses and the public sector in the EU'.

53 European Commission, A European strategy for data, (COM(2020) 66 final).

54 For details, see European Commission, Experts say privately held data available in the European Union should be used better and more (information webpage, June 2020).

55 For details, see European Commission, Meetings of the Expert Group on Business-to-Government Data Sharing, (information webpage, September 2020).

56 European Commission, Proposal for a Regulation on European data governance (COM(2020) 767 final).

57 To support B2B data-sharing, the Commission is also going to support through the Digital Europe programme the creation of sectoral data spaces which will have technical and governance mechanisms to share data between businesses, researchers and public organisations.

58 For instance, the Commission will adopt in 2021 the European Health Data Space, which will complement the Data Governance Act with specific rules for the use of data in the health sector.

59 See Commission work programme 2021 (p. 4) and its Annex (point 6).

- propose an **implementing act** on making public sector high-value data sets in a machine-readable format freely available for **reuse** (Q2 2021)[60].

Together with the Member States, the Commission will:

- launch a **European Alliance for industrial data, edge and cloud** in order to mobilise private and public actors to join forces and to strengthen Europe's industrial position in the global cloud and edge computing market. Its primary role will be to stimulate the coordination of public and private investments in research, development and deployment of next-generation cloud capacities at local, national and EU levels. The Alliance will be connected with the European data spaces and thus **foster innovative data-sharing environments based on open, interoperable, secure and resource-efficient cloud and edge solutions**. It will also foster synergies between the work on European cloud federation and Member States' initiatives[61];
- **invest in European data spaces and the European cloud federation**, through the Digital Europe programme, Connecting Europe Facility (CEF2) funding instruments, and other instruments, such as EU4Health for the European Health Data Space. Specifically, with first calls under Digital Europe and CEF2 to be launched in Q2 2021 the Commission will:
  - launch sector-specific actions, as announced in the European strategy for data[62], to **build European data spaces for industrial manufacturing, the green deal, mobility, health, finance, energy, agriculture, public administration, and skills**[63].
  - co-invest in the actions focusing on the development of innovative and energy-efficient cloud-to-edge services and infrastructures, middleware platforms, the interconnection of existing data-processing capacities in Member States;
- continue to support under **Horizon Europe** Cluster 4 'Digital, Industry and Space', the research, development and uptake of next-generation computing and data technologies and infrastructures, with a view of enabling the creation of a **European single market for data with the corresponding data spaces and a trustworthy and secure AI ecosystem**. The first calls will take place in April 2021; and
- accompany all interested Member States in the set-up of a possible Important Project of Common European interest (**IPCEI)** focusing on next-generation cloud infrastructure and related services.

The Member States are encouraged to:

- **invest in** strengthening Europe's position in next-generation cloud and edge technologies and foster cloud uptake through their national recovery and resilience plans and in line with the example component for the RRF 'Scale-up' flagship[64] and including through multi-country projects.

60 Based on Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (OJ L 172, 26.6.2019, p. 56). See also Chapter 14 on AI for the public sector.

61 See, for example, information on GAIA-X: A Federated Data Infrastructure for Europe project, as well as October 2020 Declaration Building the next generation cloud for businesses and the public sector in the EU.

62 European Commission, A European strategy for data (COM(2020) 66 final).

63 The Commission may consider launching additional common European data spaces in other sectors.

64 Examples of component of reforms and investments – scale-up

3. Foster critical computing capacity

Without computing infrastructure, the availability of data will not generate added value[65]. Therefore, the Commission takes measures to support the development of the technological systems and the next-generation of data processing infrastructures as a key for enabling the use of data for AI[66].

Overview of actions taken

To support the development of **High Performance Computing** (HPC) capabilities in Europe, the EuroHPC Joint Undertaking coordinates efforts and pools resources among 32 participating countries to develop and deploy a world-class supercomputing infrastructure that will be easily and securely accessible from anywhere in Europe.

The main trends for AI hardware can be summarised as follows: (1) next-generation AI solutions will need to be more powerful and more energy-efficient to meet the needs of increasingly sophisticated training models, and (2) computing will increasingly move to 'the edge', on devices that are closer to the users and able to implement real-time AI applications. Those trends require adaptation of the infrastructure and the Commission is taking steps, as outlined below, to enable the next-generation computing infrastructures.

Accordingly, the EU focuses on actions to support the development of **AI hardware**. AI models are increasingly demanding in terms of computing power, so fast access to data from memory, i.e. high-performance and efficient processors, are of paramount importance for AI infrastructures[67]. In addition, AI models are highly demanding in terms of energy and, as AI technologies penetrate more into our daily lives, such energy demand is not sustainable[68]. Therefore, AI uptake requires access to dedicated low-power AI processors that provide the necessary processing power and are more efficient, by several orders of magnitude, than general-purpose processors. In this area of research, for example, novel brain-inspired technologies, such as neuromorphic computing, have a potential to deliver ground-breaking energy efficiency. In this context, the Commission has supported pioneering work in low-power AI technologies under Horizon 2020 and is supporting initiatives for the further development and exploitation of such competences under Horizon Europe and with research actions on novel architectures for ultra-low power processors, and through the institutionalised European Partnership on Key Digital Technologies (KDT)[69], with a particular focus on edge AI applications.

The 'scale-up' flagship[70] of the 2021 annual sustainable growth strategy[71] targets, among other things, investments in cutting-edge microelectronics, with a particular focus on processors such as AI chips. In December 2020, to consolidate the EU's position in the design and production capabilities of advanced chips, 18 Member States signed a declaration on

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65 The amount of data generated by public bodies, business and citizens is expected to multiply by five in 2018-2025.

66 Computational power has also been rising exponentially. Increasingly sophisticated AI will demand more computation power from hardware. A machine-learning task can require the power of thousands of computers. Dedicated accelerators for machine learning, such as graphics processing units (GPUs), have made such deployment possible.

67 Since dedicated accelerators started being used for machine learning, AI has been doubling performance every 3,4 months, largely thanks to hardware optimisation.

68 Particularly in Edge AI applications (considering the surge of connected devices at the point of use), maximum power efficiency is essential, hence many AI functions must be implemented in hardware rather than software.

69 In this area of research, for example, novel brain-inspired technologies, such as neuromorphic computing, have the potential to deliver ground-breaking energy efficiency.

70 For more information, see RRF webpage of the Commission.

71 European Commission, Communication Annual Sustainable Growth Strategy 2021 (COM(2020) 575 final).

processors and semiconductor technologies[72]. Also, in 2019-2020, the AI4DI[73], TEMPO[74], and ANDANTE[75] projects under the Electronic Components and Systems for European Leadership Joint Undertaking (ECSEL JU)[76] addressed infrastructure for AI. Another area of development and funding supported by the Commission is photonics. Mixing electronics with optical elements can bring AI integration in image sensing and decrease power consumption and latency in neural networks.

Outlook

In order to bolster Europe's processor and semiconductor design and production system and expand industrial presence across the supply chain, **the Commission with the support of the Member States will**:

- **launch an Industrial Alliance on Microelectronics**[77] in order to establish strategic roadmaps, research and investment plans for processor design, deployment and fabrication for AI, data processing and communication, taking into account the full semiconductor ecosystem and related components.This will contribute to reinforcing the electronics design ecosystem and establishing the manufacturing capacity in very advanced nodes;
- facilitate preparatory work during 2021 with all interested Member States towards a possible Important Project of Common European interest (**IPCEI)**, focusing on the next generation of advanced processors for AI, data processing and communication;
- dedicate a **Testing and Experimentation Facility**, supported by the Digital Europe programme, on edge AI components and systems, with a call to be launched in Q2 2021, for a world-class infrastructure for testing and validation of advanced AI computing technologies in a wide range of applications;
- **invest in research and innovation** for the computing needs of low-power edge AI through the institutionalised European Partnership on KDT **under Horizon Europe** (Q3 2021). This partnership, built on the current ECSEL JU, will enhance Europe's potential to innovate in electronic components and systems, and related software technologies. One of the primary strategic objectives will be to develop AI processing solutions, particularly for edge and embedded applications. Through joint actions, KDT will provide trusted, secure and low-power solutions to enable a computing ecosystem of excellence and trust[78].

Member States are encouraged to:

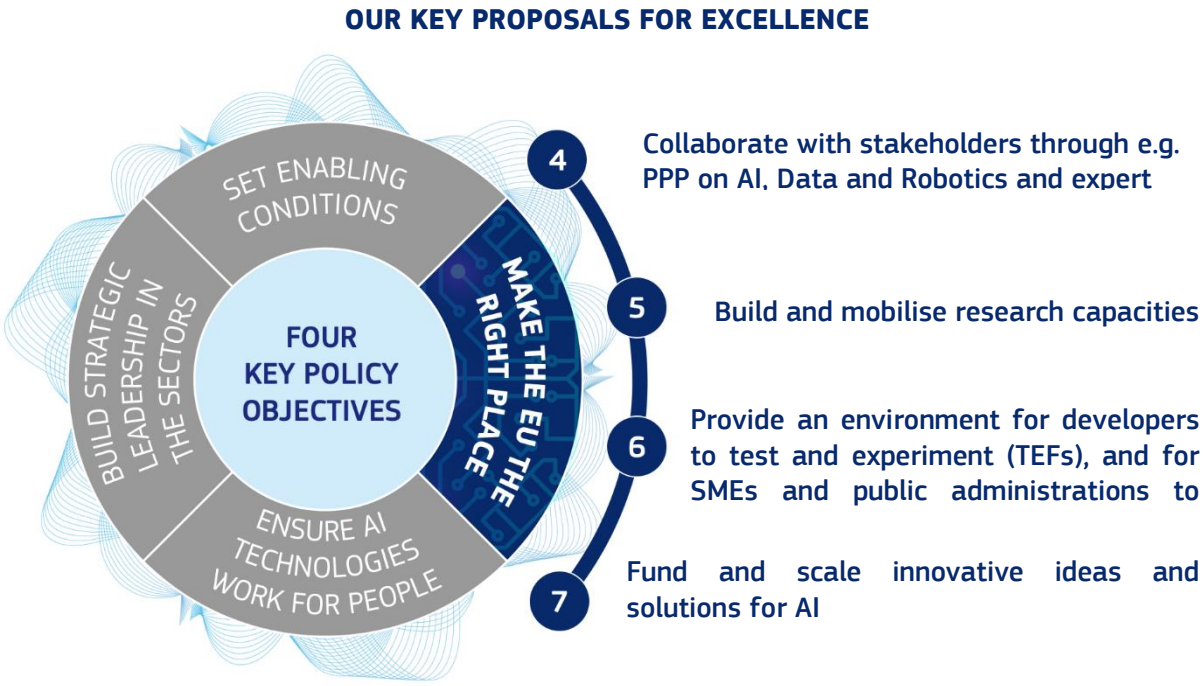
- continue the **development of national integrated large-scale data management and HPC infrastructure** to support research, innovation and skills development in AI through regional, national and European DIHs;
- ensure that academic, industry and public sector organisations can leverage national HPC and data-management infrastructure and expertise to optimise and scale up their AI innovation and applications; and
- **invest in strengthening Europe's position in processors and semiconductor technologies for AI** through their national recovery and resilience plans, in line with the

72 Member States join forces for a European initiative on processors and semiconductor technologies.
73 'AI for digitising industry' (AI4DI).
74 'Development of process technology and hardware platforms for neuromorphic computing' (TEMPO).
75 'AI for new devices and technologies at the edge' (ANDANTE).
76 For more information, see ECSEL JU webpage.
77 See 'Joint declaration on processors and semiconductor technologies'.
78 For the KDT, see also chapter four outlook

example component for the RRF 'Scale-up' flagship area and through multi-country projects.

II. MAKE THE EU THE PLACE WHERE EXCELLENCE THRIVES FROM THE LAB TO THE MARKET

The development and deployment of AI technologies, in addition to data and computational infrastructure, also require targeted actions and sufficient resources, focusing on excellence in research and innovation (R&I), availability of the requisite talent and skills, a supporting policy framework and international coordination. These actions are 'horizontal', i.e. cutting across all policy areas and help to make the European Union the place where excellence thrives from the lab to the market. The proposed 'horizontal' joint actions cover a whole AI life cycle. This includes actions to facilitate an ecosystem of excellence, including world-class foundational and application-oriented research, development, deployment and commercialisation/uptake of AI as well as measures to support trust in AI technologies, nurture talent and skills and enhance the EU's global outreach.



4. Collaborate with stakeholders through, e.g. the European Partnership on AI, Data and Robotics and expert groups

This section focuses on actions that are essential to define, and engage collectively in supporting a roadmap for excellence and for wider diffusion of AI.

Overview of actions taken

European Partnerships bring the Commission, Member States and private and/or public partners together to address and deliver on some of Europe's most pressing challenges and to modernise industry through concerted research and innovation initiatives[79]. The Partnerships

[79] Partnerships were first introduced in 2002 as part of the European Research Area to overcome fragmentation of research effort. They are funded under Horizon 2020 and, from 2021 onwards under Horizon Europe.

provide, among other things, a legal structure to pool resources and to gather critical mass and make research and innovation funding across the EU more efficient by sharing financial, human and infrastructure resources. Partnerships also facilitate the creation of an internal market for innovative products and services, enable innovative technologies to reach the market quickly, and facilitate the scale of research and innovation effort needed to address critical societal challenges and major EU policy objectives.

Several Horizon 2020 Partnerships were specifically relevant to AI technologies. The Big Data *Value Public Private Partnership* (PPP) between the European Commission and the Big Data Value Association (BDVA), aims to cooperate on data-related research and innovation, enhance community building around data, and lays the ground for a thriving data-driven economy in Europe[80]. *The Robotics PPP (SPARC)* brings together the European robotics industry, academia and the European Commission in order to strengthen the competitive position of the European robotics industry and foster the excellence of its science base[81].

The **High-Performance Computing (HPC) contractual Public Private Partnership** was launched in 2014 to develop the next generation of HPC technologies, applications and systems towards exascale[82], and to achieve excellence in the delivery and use of HPC applications[83]. As of December 2018, with the creation of **the European High Performance Computing Joint Undertaking (EuroHPC JU)**, this partnership ceased to exist, and the private side joined the EuroHPC JU. The EuroHPC JU allows the EU and EuroHPC participating countries to coordinate their efforts and pool their resources to deploy world-class exascale supercomputers and make Europe a world leader in HPC, providing computing solutions and improved cooperation in advanced scientific research.

The **Electronic Components and Systems for European Leadership Joint Undertaking (ECSEL JU)**[84] is the first Joint Undertaking to have based its governance on a tripartite model (Commission, Participating States, and Industry). It aims to secure world-class expertise in key enabling technologies and Europe's competitive leadership in hardware and embedded software essential for the development and deployment of AI-based digital systems.

The **Photonics PPP** (Photonics21)[85] aims to establish Europe as a leader in the development and deployment of photonics technologies in various fields of application, such as ICT, lighting, industrial manufacturing, life science, safety. The **Factories of the Future PPP**[86] for advanced manufacturing aims to realise the next industrial revolution (Factories 4.0).

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80 The BDVA is an association of the European big data community, which includes leading European R&I organisations and companies, including data providers, users, and analysts. The PPP was implemented in 2016-2020 through calls of proposals from the Industrial Leadership part of Horizon 2020.

81 SPARC's objective was to secure a longer-term commitment to invest in the area to develop a common roadmap for robotics in Europe and to identify the means to realise this roadmap with public support. The initiative included actions covering the full innovation cycle, from research to industry-led R&D down to testing innovative robotic technologies and piloting them in real settings.

82 Exascale computing refers to the capability to perform a billion billion (a quintillion) operations per second.

83 The HPC cPPP brought together technology providers and users via the ETP4HPC Association and centres of excellence (CoE) for computing applications. The cPPP focused on technologies and usage and applications of the European HPC strategy, along with training, education and skills development. European Commission, Proposal for a Council Regulation on establishing the European High Performance Computing Joint Undertaking, COM(2020) 569 final.

84 ECSEL Joint Undertaking.

85 Photonics 21.

86 *Factories of the Future Roadmap*, The European Factories of the Future Research Association (information webpage, January 2021).

Outlook

The Commission will continue to support European partnerships in the context of Horizon Europe and enhance the strategic approach to research and innovation (R&I) in AI technologies.

The Commission will, in 2021:

- establish among others the following European partnerships[87] of relevance to AI, including:
  - a **co-programmed European partnership on AI, Data and Robotics**[88] – the main objective is to drive innovation, uptake and acceptance of AI, data and robotics technologies[89]. The partnership will build bridges between stakeholders that enable a human-centric and trustworthy European vision of AI to flourish[90]. It will establish links to Member States and provide an overview of major national policies and initiatives by appointing national and/or regional ambassadors;
  - follow up its September 2020 proposal for a new regulation to replace the 2018 Council Regulation establishing the **EuroHPC JU** – this sets out an ambitious mission and a substantially larger budget for 2021-2033 to provide Europe with a world-leading hyper-connected supercomputing and quantum-computing infrastructure;
  - propose through the Single Basic Act an **institutionalised European Partnership on Key Digital Technologies (KDT)**. Building on the achievements of the ECSEL JU, its main objective is to advance developments to reinforce Europe's processors and semiconductor technologies' ecosystem, addressing key technological, security, societal and environmental challenges;
  - the **co-programmed European Partnership on Photonics**[91] will secure Europe's technological sovereignty through photonic innovations and their transfer into applications, improving Europe's competitiveness and ensuring long-term jobs and prosperity; and
  - the **co-programmed European Partnership 'Made in Europe'**[92] will be the driving force for sustainable manufacturing in Europe, including through AI, contributing to a competitive and resilient manufacturing industry in Europe and reinforcing added value in supply chains across sectors; and

87 Co-programmed and institutionalised partnerships initiated under Horizon Europe, see European Partnerships in Horizon Europe information webpage.

88 Co-programmed Partnership, see European Partnership on Artificial Intelligence, Data and Robotics webpage.

89 The Partnership proposal, among other things, highlights the importance of involvement of social partners in this Public Private Partnership.

90 The PPP's vision, overall goals, main technical/non-technical priorities, investment areas and a research, innovation and deployment roadmap are set out in a strategic research, innovation and deployment agenda, which will guide its activities from 2021 onwards. It is expected that the memorandum of understanding to start the PPP's activities will be signed in April 2021.

91 Photonics imaging processes are what makes AI 'see'. Photonic technologies used in AI include photonic sensor systems and image processing, e.g. low-latency, high-reliability recognition for robots/autonomous systems and smart camera platforms with embedded image processing; for more detail, see European Partnership on Photonics (draft proposal, 26 May 2020).

92 For an overview of all PPPs planned under Horizon Europe, see European Commission, Coherence and synergies of candidate European partnerships under Horizon Europe (October 2020). There are 10 PPPs planned in cluster 4 ('digital, industry and space').

– support and facilitate synergies (including the organisation of joint calls) between European partnerships (co-programmed and institutionalised) around AI technologies, such as AI, Data and Robotics, Photonics, Made in Europe, EuroHPC[93], and KDT.

5. Build and mobilise research capacities

This section focuses on measures to boost AI research and innovation excellence and to improve European competitiveness[94].

Overview of actions taken

In addition to the strategic research agendas of the Public-Private Partnerships, the EU also takes action to strengthen excellence in basic and applied research and to foster talent in Europe. Through Horizon 2020, the Commission invested EUR 50 million[95] over 4 years to create a research community of closely networked **AI excellence centres**[96]. The aim is to increase cooperation among the best research teams in Europe, so that they can join forces to tackle major scientific and technological challenges in AI, and to facilitate closer cooperation, integration and synergies between research teams and industry. Five projects have been selected to form the network, to bring together world-class researchers and establish a common approach, vision and identity for the European AI system; these include four networks of AI excellence centres and one coordination and support action[97].

In order to ensure that EU support for research keeps up with AI technological developments, the Commission has assessed its cross-sector investments in AI under Horizon 2020 against current research trends and needs, and identified future investment opportunities for AI, primarily under Horizon Europe. It has also used input from the public consultation on the AI White Paper and targeted consultation from the AI community, in particular the AI, Data and Robotics PPP, to plan new topics in AI research and additional networks of excellence centres.

Outlook

To drive excellence in research, **the Commission will:**

– set up, starting in 2021, and in close dialogue with the Member States and the wider AI community, an **AI lighthouse for Europe,** as announced in the White Paper. The AI lighthouse will build on the existing and future Networks of AI excellence centres, with the aim to build an alliance of strong European research organisations that will share a common roadmap to support excellence in basic and applied research, to align national AI efforts, to foster innovation and investments, to attract and retain AI talent in Europe, and to create synergies and economies of scale. This initiative will bring together leading players from research, universities and industry in Europe to work on commonly agreed

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93 As one of the private members in the EuroHPC JU and a key partner in the European Partnership on AI, Data and Robotics, BDVA will contribute strongly to the alignment of HPC, big data and AI strategies and roadmaps in Europe. The Partnership will further collaborate and seek to develop closer links with other European Partnerships of relevant strategic importance, e.g. on KDT, 'Made in Europe' Cooperative, connected and automated mobility (CCAM), and the Alliance for IoT Innovation.

94 The international dimension is covered in Chapter 7. The AI Watch report TES analysis of AI Worldwide system in 2009-2018 highlights the strong European research environment in AI, with the EU being the worldwide leader in number of AI frontier research players. The forthcoming report, covering the period 2009-2020, identifies the EU as the region with most strategic research players in the network of collaborations of patents and publications.

95 Estimate based on data as of September 2020.

96 These networks seek to advance research, bringing the diverse academic AI community in Europe closer together and fostering new talent. They run for 3 years (except for one which runs for 4 years). This work builds on strong EU research support funded by Horizon 2020 and the European Research Council.

97 For details see the project websites of AI4Media, ELISE, Humaine-AI-net, TAILOR and VISION (CSA).

ambitious challenges, with the overarching aim of becoming a world reference of excellence in AI. As a result, Europe's diversity will stimulate healthy competition, rather than the fragmentation of the AI community;

- fund under **Horizon Europe**, in 2021 and 2022, additional **networks of AI excellence centres** addressing complementary research areas that are not yet covered by the existing networks of AI excellence centres and reinforcing research efforts that address critical AI research topics. This will drive forward the development of safer, more secure and more trustworthy AI, support foundational and application-oriented research on next-generation AI, aiming to keep Europe at the cutting edge in AI;
- under Horizon Europe, starting in 2021, advance the state of the art in various areas of **AI research**, including, research towards the next level of intelligence and autonomy of AI-based systems, transparency in AI, greener AI, AI for complex systems, advances in edge AI networks, unbiased AI systems, empowering humans with advanced AI support;
- in addition to developing enabling technologies, the Horizon Europe programme will also demonstrate how AI helps transform **major economic sectors** in production and services, including implications on labour[98], and address **major societal challenges** in areas such as healthcare, civil security, climate change, energy, mobility, media (e.g. addressing disinformation) and agri-food;
- in the context of the co-programmed European Partnership on AI, Data and Robotics, mobilise stakeholders via the strategic **research, innovation and deployment agenda**[99] to develop and implement the **research, innovation and deployment strategy** for Europe, with a focus on the responsible development and use of AI; and
- have the aim that AI-related projects that receive R&I funding under the Horizon Europe adhere, as appropriate, to the **'ethics by design'** principle, including for trustworthy AI. Furthermore, in order to achieve a diverse AI research community, the Commission advocates diversity and inclusiveness in project consortia.

Member States are encouraged to:

- **set up regional and national research excellence centres around AI**, for example by using national funding instruments and RRF funds, and create a research and technology transfer structure able to attract and retain talent while at the same time aiming to become a national reference point for AI research and development. The centres would ensure regional outreach and exchange, collaborate at the European level and, together with the EU-funded networks, build the distributed European AI lighthouse; and
- strengthen **investment in AI research** at national level, e.g. through the RRF.

6. Provide tools through an AI-on-demand platform and an environment for developers to test and experiment (TEFs), and for SMEs and public administrations to take up AI (EDIH)

This section focuses on measures that help bring innovation from the lab to the market to ensure the broad uptake and deployment of AI technologies.

Overview of actions taken

Facilities for testing and experimenting with innovative AI systems are essential for deployment and uptake of AI technologies. This is especially important for small and

[98] For details, see Horizon Europe cluster 4: ('AI, data and robotics at work').

[99] For details, see BDVA, Release of the SRIDA for the AI, Data and Robotics PPP, (information webpage, 2020).

medium-sized enterprises (SMEs), which face difficulties in taking full advantage of the fast developments in digital technologies to become competitive and innovative[100]. In collaboration with Member States, the EU has proposed two sets of measures:

- **Testing and Experimentation Facilities** (TEFs) – i.e. technology infrastructures with specific expertise and experience in testing mature technology in a given sector, in real or close-to-real conditions. The aim is to provide developers with an infrastructure for testing AI technology before bringing it to the market; and
- **Digital Innovation Hubs** (DIHs) – 'one-stop shops' that help all companies interested to use AI to become more competitive with regard to their business/production processes, products or services by using AI technologies. European Digital Innovation Hubs provide companies with a possibility to test AI technologies before investing as well as related services, such as financing advice and advice on training and skills development that are needed for a successful digital transformation.

Testing and experimentation facilities (TEFs)

The 2018 Coordinated Plan stated that to optimise investment and avoid duplication or competing efforts, a limited number of specialised large-scale reference sites should be developed and opened to all actors across Europe. Following the adoption of the Coordinated Plan and in preparation for the Digital Europe programme, the Commission took preparatory steps to develop this concept and to prepare AI **Testing and Experimentation Facilities** (TEFs). Specifically, starting from 2019 the Commission has worked intensively with Member States to refine the concept of TEFs and to prioritise relevant sectors. In January 2020, the Commission organised five workshops, involving stakeholders from industry, academia and Member States, to discuss TEFs for specific sectors (agri-food, manufacturing, healthcare and smart cities) and technologies (edge AI).

The results of the preparatory work and exchanges with the stakeholders suggest that experimenting and testing state-of-the-art technology in real-world environments is an essential element in bringing technology to the market and is a part of the innovation chain where Europe's AI system needs significant support to remain globally competitive.

The edge AI TEF plays a special role for the AI ecosystem of excellence. Edge AI offers clear benefits as a hardware technology: it provides real-time operations, as well as advantages in terms of security and privacy of data and energy consumption. The edge AI TEF aims, as a European platform, to enable companies of any size to test and experiment innovative edge AI components based on advanced low-power computing technologies, such as neuromorphic computing. Given EU's current dependency on computing technologies, the high costs of the necessary semiconductor equipment and need for long-term investments, the edge AI TEF is necessary to close the funding gap so that European companies get access to low-powered AI computing hardware. In other words, the edge AI TEF will endow Europe with an ecosystem of excellence that will serve as an essential instrument to achieve technological leadership in AI.

In order for TEFs to play a central role in the AI system, they should be easy to use, work under real conditions, closely involve end users and be used by developers across the private and public sector, especially SMEs[101]. Furthermore, efficient interplay between TEFs and data spaces is fundamental in creating a level playing field and ensuring non-discriminatory market access. This could be achieved, for example, by teaming up the data spaces and TEFs

[100] Only 17 % of SMEs have successfully integrated digital technologies, compared to 54 % of large companies. (DIH working group 1, Report from the working group meeting on access to finance, March 2018).

[101] Testing and experimentation facilities will provide support to SMEs to facilitate equal access.

in mutual areas of interest. TEFs have an important role in testing robustness, reliability and safety of AI technologies through testing their ability to comply with obligations that are set to be defined in AI regulation. Finally, TEF projects should interact with parallel initiatives on the European AI-on-demand platform.

Digital Innovation Hubs

In order to help European companies (especially SMEs) make the most of new technologies, the Commission launched the 'Digitising European Industry' initiative in 2016. One of the pillars of this initiative is to establish and support **Digital Innovation Hubs** (DIHs), which provide access to technical expertise and experimentation possibilities, so that companies can test before they invest[102]. DIHs also provide innovation services, such as financing advice and the training and skills development that businesses need for a successful digital transformation. Member States and regions have been investing in Digital Innovation Hubs, and the Commission (through Horizon 2020 projects in 2019 and 2020) has made available over EUR 200 million for networking the DIH. Around half of this funding was related to innovations in AI-relevant areas, including robotics and big data, and special activities were implemented for regions with few DIHs. The Horizon 2020 projects typically cascade funding through open calls to SMEs to allow them to participate in innovative experiments with DIHs in a cross-border context. The European Court of Auditors (ECA) assessed this dimension of the Digitising European Industry initiative and recommended that the Commission, in coordination with Member States, should take further action on the funding and monitoring of DIHs[103].

Support under the Digital Europe programme will address the observations of the ECA. The label **European Digital Innovation Hubs (EDIHs)** is introduced to mark the difference with the previous approach funded under Horizon 2020. The EU and the Member States will invest EUR 1,5 billion to set up a network of around 200 hubs across European regions. The grants should be used to improve the capacity of the selected EDIHs to deliver services to SMEs and the public sector. Selection and funding of these EDIHs is a joint action of the Member States and the Commission[104].

The EDIHs will stimulate the broad uptake of AI, HPC, cybersecurity and other digital technologies by industry (in particular SMEs) and by public-sector organisations in Europe.[105] They will also support them in the use of digital technology, to improve the sustainability of their processes and products, in particular with regard to energy consumption and reducing greenhouse gas emissions. They will ensure a broad geographical coverage and have both local and European functions. The EDIHs will use the tools and resources made available by the AI-on-demand platform, and will be a multiplier for the TEFs: EDIH will help companies in need to make use of the relevant TEF to innovate their new products and services and make them market ready.

AI-on-demand platform

The European AI-on-demand platform and system initiative started in 2019 and is funded under Horizon 2020. It brings together AI stakeholders and resources, thus overcoming

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102 DIHs are one-stop shops that help companies become more competitive with regard to their business/production processes, products or services using digital technologies.

103 European Court of Auditors, Digitising European industry: an ambitious initiative whose success depends on the continued commitment of the EU, governments and businesses, Special Report 19 (2020).

104 European Commission, European Digital Innovation Hubs in Digital Europe programme (22 October 2020).

105 The EDIHs will closely collaborate with the Enterprise Europe Network, the European Clusters Collaboration Platform, Startup Europe, and other relevant actors. See An SME Strategy for a sustainable and digital Europe (COM(2020) 103 final).

fragmentation and accelerating AI-based innovation (research, products, solutions). The platform under development is set to function as a European AI market driver, offering a critical mass of resources, community networking effects and rapid development and growth. Activities to consolidate the system started in January 2021 to bring in larger user communities, especially from the non-tech sector, and to facilitate the use and uptake of the platform resources.

Outlook

In order to help to bring innovation from the 'lab to the market' – to ensure the broad uptake and deployment of AI technologies, **the Commission together with Member States** will:

- co-fund **Testing and Experimentation Facilities** under the Digital Europe programme in order to provide a common, highly specialised resource to be shared at the European level and foster the speedy deployment and greater uptake of trustworthy AI across Europe. In this context:
  - the first calls (in 2021-2022) will focus on the following identified sectors: manufacturing, health, agri-food, smart communities and edge AI. The estimated budget per sector will be around EUR 20-75 million;
- select, during 2021-2022, **the network of up to 210 EDIHs** covering all regions of Europe. Regarding AI, the following specific activities are foreseen:
  - at least one EDIH in every Member State with AI expertise. The network of EDIHs will share best practices and effectively collaborate with each other (using the recommendations coming out of the AI DIH Network) to offer the best support to SMEs and public sector organisations everywhere in Europe; and
  - the network of EDIHs will work closely with the AI-on-demand platform[106], the TEFs, and the data spaces, and they will promote the use of these infrastructures to SMEs located everywhere in Europe. This will boost the dissemination of the resources and let companies experiment with AI;
- consolidate in 2021 and onwards, the **AI-on-demand** platform as a central European toolbox of AI resources needed for industry and public sector uses so that it can:
  - become the main European marketplace for AI resources; it will provide easy and simple access to AI tools[107], which will then be distributed locally by the EDIHs or used directly by the user industry (especially SMEs) or the public sector; and
  - collaborate with relevant national and European initiatives to become the central AI toolbox in Europe for anyone looking for AI expertise, technology, services and software.

The Commission encourages **Member States** to:

- **commit an equal share of funding to TEF projects**[108] selected by the Commission with the help of independent experts;

[106] The H2020-funded AI4EU project launched in 2019 is developing the first European 'AI on demand' platform. Future deployment activities of the Platform and links with TEFs and EDIHs are foreseen under Digital Europe.

[107] E.g. algorithms, software frameworks, development tools, components, modules, data, computing resources, prototyping functions.

[108] This is in line with the co-funding principles in the Regulation of the European Parliament and of the Council establishing the Digital Europe programme for the period 2021-2027 (COM(2018) 434 final – 2018/0227 (COD); publication in the Official Journal is still pending after an agreement on 15 December 2020).

- **define relevant new priorities for additional TEFs** beyond the current sectors of agri-food, manufacturing, healthcare and smart communities. Possible new sectors could be, for example, mobility, public administration or green transition;
- take full advantage of the opportunities offered by **RRF**, as well as by Cohesion Policy programmes, to fund more (E)DIHs and TEFs in order to bring innovation closer to the market; and
- support the creation of local, regional and/or national **AI marketplaces**[109] for interaction and the exchange of best practice; and facilitate scale-up across borders through the European AI-on-demand platform (central AI toolbox and marketplace), EDIHs, and Startup Europe.

7. Fund and scale innovative ideas and solutions for AI

This section focuses on support measures, with specific focus on start-ups, scale-ups, and other small and medium sized enterprises, that develop AI technologies. InvestEU and the RRF offer crucial resources to strengthen the use of financial instruments.

Overview of actions taken

To support start-ups and SMEs both in their early stages and in the scale-up phase the Commission has put forward the **AI/Blockchain Investment Scheme and its Support Programme**[110]. The pilot scheme aims to enhance the access to equity finance for innovative and higher risk AI and blockchain start-ups and SMEs with a broad geographic coverage in the EU, including less developed markets. It provides resources for investments to venture capital funds and co-investments to National Promotional Banks in Member States. Through an initial allocation of EUR 100 million from the Horizon 2020 programme, it is estimated, that the total investment volume of the fund is reaching EUR 700 million[111]. The dedicated support programme runs from 2020 to 2022.

In December 2020, the European Investment Bank Group (EIB Group) also launched a new co-investment facility of up to EUR 150 million to invest alongside funds backed by the European Investment Fund (EIF) and to support the growth of AI companies across Europe[112].

The European Innovation Council (EIC) supports AI start-ups, in development and scaling-up AI breakthrough technologies and game-changing innovations[113]. Since the launch of the pilot phase[114], the EIC supported numerous innovations in the field of AI in a wide range of scientific domains, from life sciences, food and agriculture to energy and environment-

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109 The RRF/ERDFand/or national funds could be used for the setup of regional and/or a national digital platform bringing together AI experts, solution providers and companies (including SMEs and start-ups). The next section outlines how developers of AI can also benefit from the InvestEU programme or other existing funding structures.

110 Together with the European Fund for Strategic Investments (EFSI) and the European Investment Fund (EIF).

111 First six Artificial Intelligence and Blockchain Technology funds backed by InnovFin raise a total of EUR 700 million (October 2020).

112 This funding instrument supports companies that are active in the AI sector and technologies that directly complement AI, such as blockchain, the internet of things and robotics. For additional information see European Investment Bank, EIB Group provides EUR 150 million to support artificial intelligence companies (2020).

113 The majority of EIC funding is based on a bottom-up approach designed to enable support for any technologies and innovations cutting across different scientific, technological, sectoral and application fields or representing novel scientific and technological paradigms.

114 The EIC Accelerator pilot had a total budget of more than €1,3 billion for 2019-2020. See European Commission, European Innovation Council, information webpage.

friendly technologies. For development of innovation from research projects the EIC Pathfinder pilot offers grants to promote collaborative, inter-disciplinary innovation on science-inspired and radically new future technologies. The EIC Accelerator supports scaling up of start-ups and their market entry with funding opportunities and acceleration services. The support from EIC is available to all SMEs with radically new ideas underpinned by a business plan for rolling out marketable innovation solutions and with ambitions to scale up. During its pilot phase (2018-2020), EIC provided EUR 160 million via grants and EUR 91 million through direct equity investments to AI innovative start-ups and projects involving direct or collateral research on AI technologies. In 2021, the EIC is providing over EUR 1 billion in grants and equity for start-ups and SMEs with a focus on deep tech.

The European Institute of Innovation and Technology (EIT) supports a number of initiatives to drive AI innovation forward, prepare our societies for the changes caused by AI, and educate a new generation of AI innovators. In 2019 and 2020, it allocated over EUR 22 million in its AI activities. EIT Digital and EIT Health implement the vast majority of projects related to AI. The EIT Community currently supports 120 early-to-mid stage European start-ups working in the field of AI and already invested over EUR 3 million into these companies.

In January 2021 the EIT and the EIC joined forces to fast track support to highly innovative start-ups, as well as to coordinate efforts to support women innovators and innovators from less represented regions[115]. The EIC and EIT also aim to share data and intelligence on the innovative start-ups and SMEs they support, including measurements of impacts achieved.

Outlook

The Commission with the support of Member States will:

- aim to strengthen the support and funding for the **AI/Blockchain Investment pilot** and support programme. Following the success and attractiveness of the pilot, the InvestEU programme 2021-2027 will continue to provide support investments[116] in AI/blockchain through the EIB Group and national promotional banks in order to mobilise private investments;

- fully **implement the EIC** under Horizon Europe and support disruptive innovation, with a focus on human-centric AI. This will be done through a mix of open and challenge-driven calls for funding. The 2021 EIC Pathfinder Challenge will focus on AI awareness research while the EIC Accelerator Challenge will foster strategic digital and health technologies, including medical AI. In addition, the Women TechEU initiative to be launched to support deep-tech start-ups founded and led by women;

- through Startup Europe and the Innovation Radar, mobilise **AI start-ups in** national hubs and Horizon Europe that are eager to scale up, and to meet the demand of AI expertise of SMEs embarking on digital transformation. The EDIHs funded under Digital Europe will be used to create a marketplace and organise matchmaking events for technology supply and partnerships[117];

- facilitate **exchange of information, expertise and best practice** between local, regional and national AI start-ups at European level (involving SMEs and start-ups and other

115 EIC - EIT: Working closer together for Europe's innovators (January 2021).

116 The investment guidelines of InvestEU include AI as a digital investment priority, in the section on strategic investment in critical infrastructure.

117 The first such event will be organised at a Digital Assembly under the Portuguese Presidency (first half of 2021).

relevant stakeholders) via the AI, Data and Robotics PPP, the EDIHs, the AI-on-demand platform (central AI toolbox and marketplace) and Startup Europe[118]; and

– take measures to facilitate the availability of open data and access to data for SMEs.

Member States are encouraged to:

– support AI start-ups and scale-ups in accessing finance for their growth, as well as to support SMEs in their digital transition in adopting AI technologies. Provided that the RRF objectives and conditions are met, Member States can make use of RRF funding to set up investment in the form of financial instruments (e.g. guarantees, loans, equity and venture capital instruments and the setting up of dedicated investment vehicles). Member States also have the possibility to contribute up to 4 % of their recovery and resilience plans'' total allocation to their compartment of InvestEU.

III. ENSURE THAT AI WORKS FOR PEOPLE AND IS A FORCE FOR GOOD IN SOCIETY

The AI systems increasingly being taken up in healthcare, farming, education, employment, infrastructure management, energy, transport and logistics, space, public services, security, climate change mitigation and adaptation, can help to solve complex problems for the public good. The successful development and uptake of AI contribute to EU's economic growth and global competitiveness[119] and bring enormous benefits to our society and the environment. However, some uses of AI can also challenge rights protected by EU law and trigger new safety and security concerns[120], and affect labour markets. In the 2020 White Paper on AI[121], the Commission put forward the European approach on AI that builds on an ecosystem of excellence and an ecosystem of trust for AI[122].

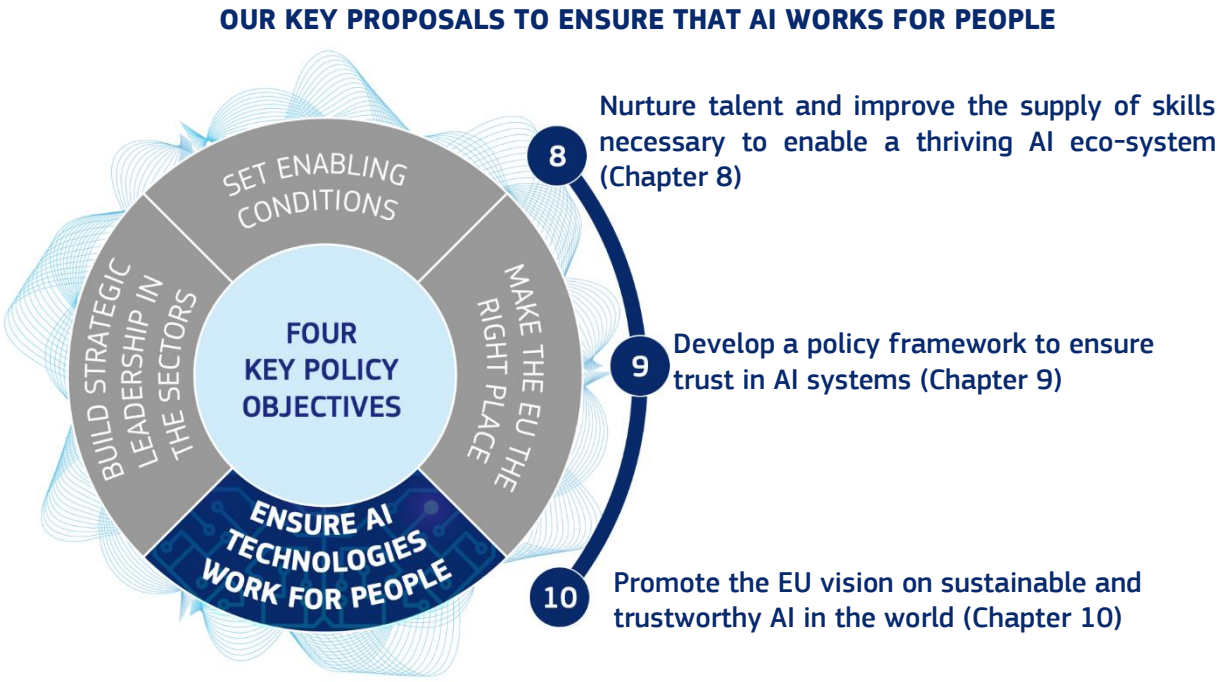
118 The EU Startup Nation Standard initiative targets Member State policies that would enable start-ups to grow in Europe.

119 According to McKinsey (Shaping the digital transformation in Europe, 2020), the cumulative additional GDP contribution of new digital technologies including AI could amount to EUR 2,2 trillion in the EU by 2030 (14,1 % increase from 2017). PwC (Sizing the prize: What's the real value of AI for your business and how can you capitalise?, 2017) comes to an almost identical forecast increase at global level (USD 15,7 trillion).

120 For review, see, e.g. Impact Assessment accompanying proposal on a European Approach to AI (forthcoming).

121 White Paper on artificial intelligence – A European approach to excellence and trust (COM(2020) 65 final).

122 The 'ecosystem of trust' focuses on measures to ensure that AI is developed in an ethical manner; the 'ecosystem of excellence' focuses on measures to promote responsible investment, innovation and implementation of AI. To enhance an 'ecosystem of trust' the Commission, together with this review of the Coordinated Plan on AI, puts forward the Proposal for a Regulation of the European Parliament and of the Council laying down harmonized rules on Artificial Intelligence (Artificial Intelligence Act) and amending certain Union Legislative Acts, COM (2021)206.



8. Nurture talent and improve the supply of skills necessary to enable a thriving AI eco-system

Overview of actions taken

The 2018 Coordinated Plan identified the significant and persistent **ICT skills gap** as a key challenge to the development of AI in Europe. With the development of the AI market and the uptake of AI technologies, it is necessary to ensure the accessibility and uptake of AI products and services. To this end, the EU should facilitate the acquisition of broad computing skills and further the understanding of AI for all citizens. In order to remain globally competitive, the EU also needs professionals from diverse backgrounds with specialised AI skills, such as data modelling, architecture and semantics to maintain a strong position in AI research and contribute to the development and roll out of AI systems. Non-technical AI skills are equally important. Improvement in computing and AI skills for all is also needed to avoid job market polarisation and a possible rise in inequality within and between countries.

The results of the 2020 survey of European enterprises suggest that one of the key barriers European companies face when adopting AI technologies is the availability of employees with adequate AI skills[123]. Similarly, the analysis by the Joint Research Centre of the Commission suggests that the development of digital skills, the awareness of AI technologies through all levels of education, lifelong-learning programmes and specialised AI skills are necessary in order to equip everyone for AI-driven transformations, to maintain the EU's strong position in AI research and to contribute to the development and roll out of AI systems[124].

[123] European Commission, European enterprise survey on the use of technologies based on artificial intelligence (July 2020). A lack of skills amongst existing staff was reported as a key barrier by 45 %, difficulties hiring new staff with the right skills 57 %. According to some estimates by the industry, Europe's AI expert population could more than double if new and specific learning opportunities were put in place, LinkedIn 2020.

[124] Craglia (Ed.) Artificial intelligence a European perspective, JRC Science for Policy report, 2018.

All Member States that have adopted national AI strategies have integrated the skills dimension into their strategies, as suggested in the 2018 Coordinated Plan[125]. Measures proposed in the national strategies include, for example, reforms of the formal education systems to introduce or strengthen the teaching of computational thinking, computing and AI foundations at primary or secondary school, as well as initiatives to adapt lifelong learning and reskilling policies[126]. In this context, the RRF also offers the unprecedented opportunity to support digital skills development, including in AI, at all levels of education (formal and informal) and training, as an important element to reach the 20 % digital target. As part of the objectives for the Recovery and Resilience Facility, developing digital skills at all levels is a condition to ensure that all Europeans can participate in society and take advantage of the digital transformation. Hence, in the Annual Sustainable Growth Strategy 2021[127], the Commission proposes a Reskill and Upskill flagship to encourage investments and reforms that Member States can undertake to improve digital skills, including AI and educational as well as vocational training for all ages.

In September 2020, the Commission adopted a new **Digital Education Action plan** for the period 2021-2027. This action plan integrates specific actions for the improvement of AI skills into the larger context of promoting digital skills[128]. The Commission has also supported **EU Code Week**[129], a volunteer-led movement that brings computational thinking, coding, robotics, tinkering with hardware, computer science, AI and digital skills to as many people as possible[130]. At the end of 2020, in order to support Member States in their effort to increase the specialised education offer in AI, the Commission awarded grants to **four university networks, SMEs and AI excellence centres to deliver excellent master's programmes in AI**, for a total of EUR 6,5 million. The selected networks should, with the support of the EU funding, jointly design and deliver high-quality and hands-on master's programmes in different Member States, with a specific focus on human-centric AI, AI application for the public administration and AI for healthcare[131]. All the programmes should

125 Moreover, Member States' academic institutions have increased their specialised education offer in AI at tertiary level. For example, the number of master's specialised courses in AI has increased by 10 % from 2018 to 2019. There are now around 260 such courses on offer. For analysis see, e.g. Righi, R., et.al. Academic Offer of Advanced Digital Skills in 2019-20. International Comparison. Focus on Artificial Intelligence, High Performance Computing, Cybersecurity and Data Science, JRC Technical Report, 2020.

126 For analysis see, e.g. Righi, R., et.al. Academic Offer of Advanced Digital Skills in 2019-20. International Comparison. Focus on Artificial Intelligence, High Performance Computing, Cybersecurity and Data Science, JRC Technical Report, 2020.

127 European Commission, Communication on Annual Sustainable Growth Strategy 2021 (COM(2020) 575 final). Article 19 of the Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility call for the mainstreaming of gender equality and equal opportunities for all in the national recovery and resilience plan. This is particularly relevant, for example, in regard to the development and upskilling of digital and AI skills for women and girls.

128 In particular, the plan includes a number of support activities that among other things should facilitate indirectly the development of AI skills, including actions to: improve high-speed internet connection for education, boost the digital capability of schools and support innovation though the use of emerging technologies such as AI for better learning and teaching, improve the teaching of informatics and computational thinking in education extending successful projects such as the Digital Opportunity Traineeships that supports cross-border experiences for students to improve their digital skills on-the-job. In its pilot version the scheme has reached 16 000 students in 2 years.

129 EU Code week is a grassroots initiative which aims to bring coding and digital literacy to everybody in an engaging way (2021). 'Tutorials' and lesson plans on tinkering and robotics are also available for beginner teachers.

130 EU Code week; by the end of 2020, more than 14 million young people had participated in Code Week, nearly half of them girls. In 2021, EU Code Week will provide a free massive open online course (MOOC) on AI basics for schools for teachers. Tutorials and lesson plans on introducing AI in the classroom are also available.

131 European Commission, Universities, SMEs and researchers join forces to deliver new Master courses in AI, 2021.

also include AI ethics courses and part of the content should be made available online through the Digital skills and jobs platform translated into all EU languages[132].

Outlook

The Commission will:

- As a part of the actions planned in the **Digital Education Action Plan** 2021-2027:
  - support traineeships in digital areas, extending the possibility of participating to vocational education students and teaching staff, in addition to university students, with an increased focus on AI skills and with particular attention to the principle of non-discrimination and gender equality; and
  - develop ethical guidelines on AI and data usage in teaching and learning for educators as well as the support of related research and innovation activities through Horizon Europe. This Action will build on the work of the High-Level Expert Group on AI on ethical guidelines[133]. The guidelines will be accompanied by a training programme for researchers and students on the ethical aspects of AI and include a target of 45 % of female participation in the training activities;
- support the development of new skills intelligence, under the Skills Agenda of July 2020, including at regional and sectoral level. Specifically, building on the work by Cedefop (Skills-OVATE project[134]) and using AI technology to carry out big data analysis based on scraping job adverts to obtain real time information on current and emerging skills demand. In this context, a permanent online tool is to be created where real-time information will be published which all interested stakeholders can use;
- support initiatives that facilitate the mutual recognition of AI specialised higher education programmes in the EU[135];
- under the **Digital Europe programme,** support measures including design and implementation of specialised education programmes, modules and short-term training courses in key capacity areas, also for professionals in different sectors to become proficient in the use of digital technologies. The call for the specialised programmes will be launched in Q1/2 2021 and the short-term training courses in Q1 2022. All available opportunities and tools for digital skills development will be showcased on the Digital Skills and Jobs Platform;
- under the **Horizon Europe** programme, support Networks of AI excellence centres (as part of the AI lighthouse)[136]. Among other tasks, the centres would:
  - explore options to retain talent through closer collaboration with industry and public authorities; and
  - develop PhD programmes and AI modules that could be integrated in non-ICT education master programmes;
- fund doctoral networks, postdoctoral fellowships and collaborative staff-exchange projects in AI under the **Marie Skłodowska-Curie actions**. The calls for Individual

132 The initiative will be supported by the CEF to be implemented in 2021.

133 See Section 1.2 on High-Level Expert Group on Artificial Intelligence.

134 See Skills-OVATE: Skills Online Vacancy Analysis Tool for Europe.

135 One suggestion put forward in the JRC 2021 Working document (forthcoming) to facilitate mutual recognition is, for example, to develop an EU label for those master's programmes covering the necessary AI contents to be considered as 'EU AI master's'.

136 Towards a vibrant European network of AI excellence (October 2020).

Fellowships and Innovative Training Networks (renamed Postdoctoral Fellowships and Doctoral Networks) are planned for Q2 2021. The calls for Research and Innovation Staff Exchanges (renamed Staff Exchanges) and COFUND are planned in Q4 2022[137]; and

- **promote gender equality** through Horizon Europe, including in the projects related to AI. The integration of the gender dimension into research and innovation content becomes a requirement by default across the whole programme. Starting in 2022, a new eligibility criterion to get access to Horizon Europe funding will be introduced. Public bodies, research organisations and higher education establishments will be required to have a gender equality plan for all Horizon Europe funded projects[138].

Member States are encouraged to:

- **refine and implement the skills dimension** in their national AI strategies, in collaboration with social partners, e.g. to:
  - promote the development of computational thinking of pupils, students and educators in formal, informal and non-formal education at all levels and support dedicated initiatives that encourage young people to choose AI subjects and related fields, such as robotics, as a career;
  - create outreach programmes for teachers on including AI in school, both in ICT skills and from a broader perspective;
  - increase the availability of training in AI, also by financing AI modules in humanities and social science master programmes, lifelong learning activities, training of judges, lawyers and public officials, as well as reskilling people from non-technical backgrounds in the basics of AI and the implications of it for their field of work; and
  - test, assess and, if successful, support the implementation of educational AI technologies in primary and secondary education to facilitate individual learning requirements (e.g. cognitive, AI-based tutoring);
- **exchange best practices on how to integrate AI into general education and other specialised programmes** (such as healthcare, law, social sciences, business)[139], and on promoting both broad and specialised knowledge on AI in lifelong learning;
- take measures and **exchange best practices to increase inclusion and diversity**, i.e. to facilitate balanced AI teams and attract talent in AI education, especially postgraduate studies, and training, as well as development of AI technologies; and
- make the best of the **unique opportunity provided by the RRF to finance ambitious upskilling and reskilling initiatives** as mentioned above.

137 In the past (2014-2020), MSCA Individual Fellowships and Research and Innovation Staff Exchanges attracted the most AI-related projects (384 and 76 respectively), followed by Innovative Training Networks (102) and COFUND (12). For an overview and discussion on the AI projects funded under Horizon 2020 Marie Skłodowska-Curie Actions, see, e.g. Research Executive Agency, *Meeting Report and Key Messages for Policy Consideration* Artificial Intelligence Cluster Meeting, 2020.

138 European Commission, Communication, A new ERA for Research and Innovation (COM(2020) 628 final). See also European Commission, Gender Equality a Strengthened Commitment in Horizon Europe, February 2021.

139 Only 3 % of all master's courses in business include AI modules (*Academic offer of advanced digital skills in 2019-2020*, JRC).

9. Develop a policy framework to ensure trust in AI systems

Trust is essential to facilitate the uptake of AI technologies. The European approach on AI, as proposed in the 2020 White Paper on AI, 'aims to promote Europe's innovation capacity in the area of AI while supporting the development and uptake of ethical and trustworthy AI across the EU economy. AI should work for people and be a force for good in society'[140]. Given the major social and environmental impacts of AI technologies, a human-centric approach to their development and use, the protection of EU values and fundamental rights such as non-discrimination, privacy and data protection, and the sustainable and efficient use of resources are among the key principles that guide the European approach.

Overview of actions taken

The Commission has put considerable effort into mobilising expertise[141], consulting with a wide spectrum of stakeholders (including social partners, non-governmental organisations, industry, academic community, regional authorities and Member States)[142] and developing policy actions to facilitate trust in AI.

Specifically, actions to facilitate trust have focused on issues relating to ethics, safety, fundamental rights, including the right not to be discriminated against, liability, the regulatory framework, innovation, competition[143], and intellectual property (IP).

Focusing on fundamental questions of ethics and AI technologies, the Commission has established and facilitated work of **the High Level Expert Group on AI** (AI HLEG)[144]. The group has produced two main deliverables: Ethics Guidelines for Trustworthy Artificial Intelligence[145] and an Assessment List for Trustworthy AI (ALTAI)[146]. The Ethics Guidelines identified key principles and requirements for Trustworthy AI[147] and the Assessment List provided an operational framework to support application of ethical guidelines by AI developers and users. The AI HLEG's work has triggered important debates on the European vision and approach to AI policy, and provided input to the development of a regulatory framework on AI[148].

In February 2020, the Commission published a White Paper on AI and a Report on the safety and liability implications of AI, the internet of things and robotics. The White Paper and the report have outlined the strategic vision and the proposal for the possible EU regulatory framework on AI. In terms of EU regulation the Commission proposed to focus on three interrelated issues: development of the horizontal regulatory framework on AI focusing on issues of safety and fundamental rights, issues of liability of AI and revision of the existing

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140 See above, p. 24.

141 See Section 1.2.

142 The Commission's proposals in the 2020 White Paper on AI triggered a wide public consultation on how to develop ecosystems of excellence and trust in AI in Europe.

143 Member States were also consulted on potential barriers to the development of AI resulting from competition and State aid rules. The results did not provide evidence that the rules present barriers.

144 See Section 1.2.

145 The Commission endorsed the guidelines in the *Communication on Building trust in human-centric artificial intelligence* (COM(2019) 168 final).

146 European Commission High-Level Expert Group on AI, Assessment List for Trustworthy Artificial Intelligence for self-assessment, 2020.

147 This followed the December 2018 publication of the first draft of the guidelines, on which more than 500 comments were received through an open consultation. See on AI HLEG, *Ethics guidelines for trustworthy AI*, (2019).

148 Additionally, work of the JRC focused on trustworthy AI and the impact of AI on human behaviour studies aspects such as the occupational impact of AI, social robots and human development, diversity in AI, among others. HUMAINT. Understanding the impact of Artificial intelligence on human behaviour.

sectoral safety legislation when necessary.[149] The Commission's work programme indicated that the Commission intends to propose those legislative actions in 2021.

On 16 December 2020, the Commission and the High Representative of the Union for Foreign Affairs and Security Policy adopted the EU **Cybersecurity** Strategy for the Digital Decade[150] that sets out how the EU will shield its people, businesses and institutions from cyberthreats, and how it will advance international cooperation and lead in securing a global and open internet. Furthermore, to address specific AI-related cybersecurity risks, the EU Agency for Cybersecurity (ENISA) established a multidisciplinary Ad Hoc Expert Group on cybersecurity topics related to AI.

In its Intellectual Property (IP) action plan, the Commission highlighted some of the challenges posed by AI systems for **IP rights**[151]. The available evidence suggests that the EU's IP framework is broadly suitable for addressing the challenges raised by AI-assisted output. However, there is still room for improvement and further harmonisation. The IP Action Plan proposes action on certain issues, in particular by engaging with stakeholders and collecting evidence to inform policymaking.

The debates on trust issues and regulation focused, among other things, on the question of **innovation**, i.e. how to design public regulation that will facilitate and not stifle innovation and thus enhance European competitiveness. Accordingly, to develop a dynamic regulatory approach, the Commission has widely consulted on both the choice of form and the content of the regulatory framework[152]. The main lessons learned are that the EU's approach should be human-centric, risk-based, proportionate and dynamic. One element of designing regulatory environments that are conducive to innovation, suggested by various stakeholders, is regulatory sandboxes. Regulatory sandboxes, in essence provide an experimentation facility for public regulation, and allow a more rapid evaluation of the impact of public intervention. The feedback received by the Commission indicates widespread support for regulatory sandboxes, with a number already established in Member States and many others under consideration across various sectors.

Outlook

The Commission will:

- Propose in 2021 **legislative action on a horizontal framework for AI**, focusing on issues of safety and the respect for fundamental rights specific to AI technologies.
    - The proposed framework provides a definition of AI, it is risk-based (i.e. defines what a 'high risk' AI is) and lays down mandatory requirements for high-risk AI systems. It also proposes a governance mechanism that covers both *ex ante*

149 For example, the White Paper on AI, indicated that the Commission is examining specific AI challenges in the healthcare sector.

150 JOIN(2020) 18 final.

151 European Commission, Communication on 'Making the most of the EU's innovative potential. An intellectual property action plan to support the EU's recovery and resilience. See, for example, M. Iglesias, et.al., Intellectual property and artificial intelligence – a literature review' (JRC report, 2019), which discusses the possible implications of the use of AI in the IP legal framework. See also 'Copyright and new technologies: copyright data management and artificial intelligence' (SMART 2019/0038) and 'Trends and development in AI: challenges to the IPR framework' (SMART 2018/0052). The latter presents the state of the art on copyright and patent law protection for AI-assisted creations, and will be taken as the starting point for more detailed elaboration and discussion of policy options and solutions. See also the study on the application of the Trade Secrets Directive in the context of the data economy (GRO/SME/20/F/206).

152 One section of the public consultation on the White Paper on AI as well as consultations leading to the Impact Assessment to support the proposal for a regulatory framework have specifically focused on this issue.

conformity assessments and an *ex post* compliance and enforcement system. Outside of the high-risk category, all providers of AI systems are subject to the existing legislation and transparency requirements, and additionally could choose to subscribe to voluntary, non-binding, self-regulatory schemes, such as codes of conduct;

- propose in 2022 **EU measures adapting the liability framework to the challenges of new technologies, including AI** to ensure that victims who suffer damage to their life, health or property as a result of new technologies have access to the same compensation as victims of other technologies. This may include a revision of the Product Liability Directive[153], and a legislative proposal with regard to the liability for certain AI systems. Any new or amended provisions of existing legislation will take into account other existing EU legislation, as well as the proposed horizontal framework for AI;
- propose in 2021 and onwards as necessary **revisions of existing sectoral safety legislation**, including: targeted adaptations of the Machinery Directive[154], the General Product Safety Directive, the Radio-Equipment Directive and the harmonised product legislation that follows the horizontal rules of the New Legislative Framework[155]. Any new or amended provisions of the existing legislation will take into account the existing EU health and safety at work legislation;
- continue to cooperate closely with and actively involve a broad spectrum of stakeholders to **promote ALTAI** in sectoral contexts and specific areas of application and implementation. Further actions may focus on, for example, establishing metrics and methods to assess and monitor the impact of AI systems on environmental and societal well-being, inclusion and diversity, as well as measures to ensure trustworthy AI in public procurement. The Horizon Europe and Digital Europe programmes could fund mechanisms to support such initiatives, which Member States could further support through the RRF;
- organise in 2021 **stakeholder dialogues** with industry and other stakeholders on IP and new technologies;
- further strengthen cooperation with **EU agencies and other relevant EU bodies** working on AI[156];
- collaborate with the European **standard setting organisations,** on the basis of mapping of existing standardisation activities and requirements arising from the proposed regulatory framework; and
- explore establishing national, regional or **sectoral Security Operation Centres** as outlined in the new EU cybersecurity strategy, potentially as an multi-country project[157].

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153 See Evaluation SWD(2018) 157 final of Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products, accompanying Report COM(2018) 246 from the Commission to the European Parliament, the Council and the European Economic and Social Committee on the application of the Directive; See also Report COM(2020) 64 on the safety and liability implications of Artificial Intelligence, the Internet of Things and robotics.

154 Proposal for a Regulation of the European Parliament and of the Council on machinery products, COM(2021) 202.

155 The Commission intends to adopt proposal for the revision of the GPSD second quarter of 2021. In addition, delegated acts are expected to be soon adopted by the Commission under the Radio Equipment Directive 2014/53/EU to enact certain new requirements on data protection and privacy, cybersecurity and harm to the network, and against fraud.

156 For example, the European Union Agency for Cybersecurity (ENISA) may update the AI threat landscape in the light of technological development and new challenges.

157 The EU cybersecurity strategy for the digital decade (JOIN(2020) 18 final).

These centres, powered by AI to improve the detection of malicious activities and dynamically learn about the changing threat landscape, will constitute a 'cybersecurity shield' for the EU, able to detect signs of a cyberattack early enough and to enable proactive action, for enhanced joint risk preparedness and response at national and EU level.

The Commission and Member States will:

- cooperate and coordinate efforts to ensure the timely and smooth **implementation of the EU legal framework** for AI. Specific actions, to be defined and launched in line with the adopted legislation may include, for example, capacity-building initiatives for national competent authorities and notified bodies that would be responsible for *ex ante* conformity assessment procedures of certain high-risk AI systems, developing guidance documents and toolkits; those activities are tentatively planned for 2022 onwards;
- continue to engage also in 2021 and onwards with European standardisation organisations and all relevant stakeholders to ensure timely adoption of harmonised standards necessary for the operationalisation of the requirements and obligations envisaged in the legal framework. The development of these additional standards can be based, for example, on standardisation requests issued by the Commission according to Article 10 of Regulation (EU) No 1025/2012; and
- analyse in 2021-2022 the feasibility of using TEFs, EDIHs and the AI-on-demand platform to assist already established national bodies in assessment and certification of AI technologies.

10. Promote the EU vision on sustainable and trustworthy AI in the world

Asserting Europe's global leadership and promoting the development of human-centric, sustainable, secure, inclusive and trustworthy AI will build further on the actions undertaken since the 2018 Coordinated Plan. In line with the Joint Communication on strengthening the EU's contribution to rules-based multilateralism and as set out in the Commission 'Communication on 2030 Digital Compass: the European way for the Digital Decade', the international dimension is more essential than ever. The implications of new digital technologies such as AI transcend borders and need to be addressed globally.[158]

The EU will promote ambitious global rules and standards, including strengthening cooperation with like-minded countries and the broader multi-stakeholder community and in a Team Europe spirit to support a human-centric and rules-based approach to AI. In order to be effective, the EU's approach will continue to be based on a proactive approach in various international bodies to build the strongest possible coalition of countries that share the desire for regulatory guardrails and democratic governance that benefit our societies. At the same time, the EU will reach out to other partners and seek common ground on an issue-by-issue basis to address the vast array of opportunities and challenges related to AI.

Overview of actions taken

International bodies such as the United Nations (UN), the UN Educational, Scientific and Cultural Organisation (UNESCO), the Organisation for Economic Cooperation and Development (OECD), the Council of Europe, the G7 and the G20 are working on AI issues[159]. International standardisation organisations such as the International Organisation for

[158] Joint Communication on strengthening the EU's contribution to rules-based multilateralism (February 2021).

[159] E.g. the OECD principles on AI adopted by OECD member countries in the OECD Council Recommendation on Artificial Intelligence (OECD/LEGAL/0449) in May 2019, the Saudi G20 Presidency AI Dialogue under the

Standardisation (ISO) and the Institute of Electrical and Electronics Engineers (IEEE) are engaged in manifold standardisation activities in the field. The 2018 Coordinated Plan emphasised that the development of AI would benefit from international cooperation, in particular with advanced countries with R&I strengths and investments in AI, and stressed the merits of development of international standards to facilitate AI deployment and acceptance. The EU's cooperation with international bodies has also proved effective in identifying risks and malicious uses associated with AI[160].

The EU participates actively in the global dialogue and promotes a European vision of trustworthy AI at global level, for example:

- The EU is a founding member of the new **Global Partnership on AI** (GPAI) launched in July 2020, with strong representation in the four working groups on: data governance, responsible AI (including a subgroup on pandemic response), the future of work; and commercialisation and innovation[161].
- The EU also contributes significantly to the **OECD**'s work on AI, through its involvement in the ONE-AI experts group[162] and collaboration of AI Watch on collection and publication of national AI strategies[163].
- In September 2020, the Commission launched a large **foreign policy instrument** project to engage with international partners on regulatory and ethical matters and promote the responsible development of trustworthy AI at global level.
- The revision of the **Dual-Use Regulation**[164] will allow the EU to set new rules allowing for more accountability and transparency in the trade of dual-use items, helping to ensure that there is no misuse of AI from Europe.
- The EU has bilateral structured dialogues, among others, with Canada and Japan. A joint EU-Japan committee on AI held its first meeting in November 2020 and options for reinforced cooperation with Canada on AI have been discussed. Work has also started on a joint AI task force with India and there are plans to start discussions with Australia and Singapore.
- Dialogue with the United States on the development and roll out of trustworthy AI is ongoing. The Commission and the High Representative have jointly set out their ambitions for a new, forward-looking transatlantic agenda, including digital and other technology issues. The Commission is notably proposing the setting up of an EU-US Trade and Technology council. Concretely the Commission will work towards an AI Agreement with the US[165]. There are several channels for discussion with US

Digital Economy Task Force (DETF), to help advance the G20 AI principles (2019), Unesco's draft Recommendation on the Ethics of Artificial Intelligence, and the ITU's AI for Good Global Summit, the leading action-oriented, global and inclusive UN platform on AI.

160 *Malicious uses and abuses of artificial intelligence*, Europol, UNICRI and Trend Micro joint report (2021).

161 Plonck, A., The Global Partnership on AI takes off – at the OECD, 9 July 2020.

162 OECD, *OECD Network of Experts on AI (ONE AI)*, information webpage (2020).

163 See European Commission: *European Commission and OECD collaborate on global monitoring and analysis of Artificial Intelligence developments* information webpage, (February 2020).

164 See Article 5, Article 10 and Article 26(2) of the position of the European Parliament P9_TC1-COD(2016) 295 on the provisional agreement reached in November 2020 between and the European Parliament, the Council and the Commission on the final text of the (recast) Council Regulation (EC) No 428/2009 of 5 May 2009 setting up a Community regime for the control of export, transfer, brokering and transit of dual-use items. The Council is expected to agree to the updated regulation in the course of April 2021, before it can enter into effect (90 days after its publication).

165 JOIN(2020) 22 final.

representatives (e.g. the EU-US Information Society Dialogue)[166] and various institutions/think tanks[167].

- The EU continues to support international standardisation bodies in their work to define common standards in the global governance of AI. To this end, the Commission actively engages in ongoing discussions with leading standardisation organisations, such as the ISO and IEEE, in order to exchange best practices and promote its vision for the responsible development and deployment of AI across the world.
- The Commission has also participated in the World Intellectual Property Organization (WIPO) public consultation on AI and IP[168] and is actively participating in WIPO discussions.

Outlook

The EU will step up its bilateral and multilateral efforts to support the establishment of a global level playing field for trustworthy and ethical use of AI, building notably on a strong transatlantic cooperation but also through a wider coalition of like-minded partners.

The Commission will:

- continue to **participate in, facilitate and support international, multilateral and bilateral discussions on trustworthy AI** founded on an open value-based approach and promote the EU's approach to AI on the global stage, i.e. through regulatory cooperation, strategic communication and public diplomacy;
- **foster the setting of global AI standards** in close collaboration with international partners and continue to participate in the WIPO work on AI and IP rights; and
- intensify efforts in bilateral exchanges with third countries through **structured dialogues and joint initiatives on AI**. This will include joint projects such as the Horizon 2020 EU-funded EU-Japan AI project for smart manufacturing[169].

Member States and the EU will:

- continue their **international outreach efforts** on AI and ensure that Europe sends consistent messages on trustworthy AI to the world. Additionally, the Union will continue to contribute its **expertise and dedicated financial means to anchor AI more firmly in diplomacy and in development policy** with a particular focus on southern Mediterranean countries and Africa; and
- facilitate exchanges with global players on **best practices** for the assessment, testing and regulation of AI applications.

IV. BUILD STRATEGIC LEADERSHIP IN HIGH-IMPACT SECTORS

In addition to the horizontal actions, the 2021 review of the Coordinated Plan puts forward **seven sectoral action areas**. In order to align joint actions on AI more closely with the

166 European Commission, Joint Statement on the 17th European Union – United States Information Society Dialogue, information webpage, (July 2020).

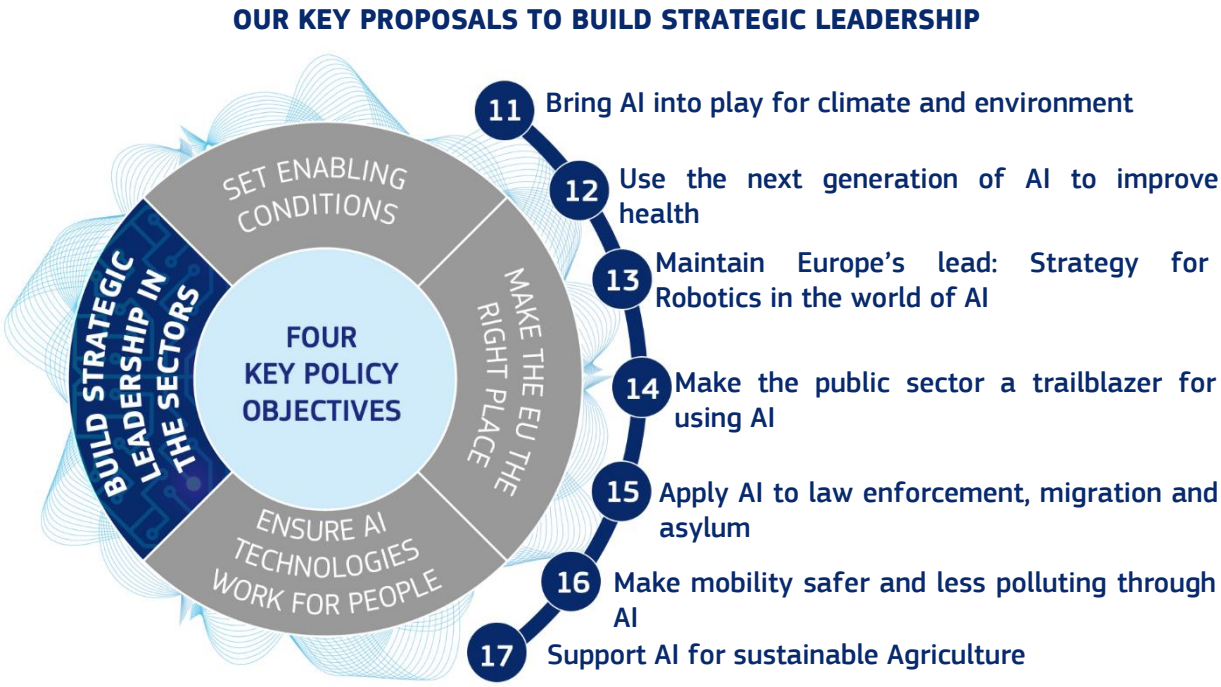
167 This includes working-level and high-level discussions with the US National Security Commission on Artificial Intelligence, contributions to the CEPS/Brookings transatlantic dialogue process and contributions to German Marshall Fund-sponsored events on biometric information processing and facial recognition.

168 WIPO, *WIPO begins public consultation process on artificial intelligence and intellectual property policy*, information webpage (13 December 2019).

169 For details on the project, see European Commission: Advancing Collaboration and Exchange of Knowledge Between the EU and Japan for AI-Driven Innovation in Manufacturing. Information webpage, 2020.

European Green Deal and the EU measures in response to the COVID-19 pandemic, the review proposes actions on **environment** and **health**. This alignment and reinforcement of joint actions is necessary to contribute to systemic changes and the EU's commitment to 'greening the economy'. AI tools and applications, such as 'digital twins' of the Earth, will be indispensable if the EU is to achieve its objectives in terms of climate neutrality, overall lower consumption of resources, greater efficiency and a more sustainable EU in line with the United Nations' 2030 Agenda and sustainable development goals (SDGs).

In the fight against COVID-19, AI has shown its versatility, e.g. by contributing to analyses of computed tomography (CT) scans (to spot early signs of infection) and to the development of vaccines[170]. The pandemic has also underlined the importance of digitally enabled new ways of working and the significance of cooperation between Member States for the benefit of the economy and the public at large.[171] To align with market developments and ongoing actions in Member States, the review also proposes joint actions on **robotics, public sector, mobility, home affairs and agriculture**.



11. Bring AI into play for climate and environment

Reasons for joint actions:

The EU aims to cut greenhouse gas emissions by at least 55 % by 2030 and to be climate neutral by 2050[172]. Development and widespread uptake of climate- and environmentally friendly AI solutions have a strong potential to help meet these ambitious targets. This has been underlined in the recent Environment Council conclusions highlighting the role of AI in

170 For more details, see, for example, 'Imaging COVID-19 AI initiative'. This is a multi-centre European project to enhance computed tomography (CT) in the diagnosis of COVID -19 by using deep-learning AI technology for the automated detection and classification of COVID-19 on CT scans, and for assessing disease severity in patients by quantifying lung involvement. The project is supported by the European Society of Medical Imaging Informatics (EuSoMII).

171 See, for example, De Nigris S. et.al, 'AI and digital transformation: early lessons from the COVID-19 crisis', JRC Science for Policy Report, 2020.

172 European Commission, The European Green Deal COM(2019) 640 final, December 2019.

achieving the goals of the European Green Deal[173]. The conclusions stressed the importance of focusing on the potential direct and indirect negative environmental impacts of AI, encouraged Member States to share experiences and lessons learnt and called the Commission to develop indicators and standards on the negative impact of digitalisation. In March 2021, 24 Member States, Norway and Iceland signed a declaration to accelerate the use of green digital technologies for the benefit of the environment, i.e. by encouraging the development and use of energy-efficient algorithms[174].

In addition to the reduction of the greenhouse gas emissions, AI could also help make the clean transition more affordable, acceptable and circular. Optimisation of connectivity to energy, transport and communication networks and addressing climate and environmental problems, including waste management and reuse, single-use plastics, the depletion of natural resources, water and air pollution, adaptation to climate change and loss of biodiversity[175]. In this context, AI technologies could primarily support the achievement of the Green Deal objectives through four main channels:

- transition to a circular economy, e.g. by making production processes more efficient and less resource- and energy-intensive;
- better setup, integration and management of the energy system and empowering businesses, public authorities and citizens to choose the most sustainable and efficient energy options;
- decarbonisation of buildings, agriculture and manufacturing; and a more efficient management of transport flows in all modes: road, rail and air, thereby reducing congestion, facilitating inter-modality and by contributing to the rollout of electric self-driving vehicles in public and private transport; and
- enabling completely new solutions that were not possible using other technologies.

AI has a key role to play in generating policy-relevant data, information and knowledge to achieve Green Deal targets effectively and efficiently and allowing for tailored interventions. The public sector should lead by example in the development and demand of sustainable AI[176]. AI-powered urban solutions is one example where cities and communities can benefit from AI to achieve environmental and climate objectives. While AI has a strong potential to facilitate the achievement of EU climate and environment objectives, the technology itself has a significant environmental footprint, especially in terms of energy consumption. Therefore, further assessment and actions are necessary to ensure that the net environmental impact of AI is positive.

Outlook

In order to bring AI into play for climate and environment, **the Commission will**:

- accelerate research and development focusing on AI's contribution to **sustainable production** and major application sectors through the Horizon Europe programme:
  - support R&I in AI for zero-defect production, towards zero-waste, zero-emission and for smart manufacturing in 2021;

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173 The Environment Council of 17 December 2020 addressed the twin societal challenge of digital transformation and green transition in Digitalisation for the Benefit of the Environment - Council conclusions 17 December 2020 and, i.e. addressed the potential direct and indirect negative environmental impacts of AI, importance of Member States to share experiences and lessons learnt in the context of the development and application of AI for the environment.

174 Ministerial declaration, A Green and Digital Transformation of the EU, March 2021.

175 See, for example, European Commission, Digital solutions for zero pollution for a wider discussion of AI-based solutions in different settings, including manufacturing and agriculture, to achieve the 'zero pollution' ambition (forthcoming, spring 2021).

176 For AI in the public sector, see Chapter 14.

- support R&I in AI-based smart farming solutions with a focus on efficiency gains, tailored applications, and reduction of inputs and emissions in 2021;
- support research and development of AI-based solutions for water quality and availability monitoring; and
- help SMEs to deploy sustainable AI solutions in manufacturing with the Innovation for Manufacturing Sustainability in SMEs (I4MS2) initiative, which will finance SMEs willing to run experiments finalised to the introduction of new technology in their business, starting in 2022;

- support research towards greener AI, addressing the **energy consumption** of AI technologies through the Horizon Europe programme:
  - continue to support research on frugal AI to develop lighter, less data-intensive and energy-consuming models, with projects starting in 2022; and
  - the institutionalised European Partnership KDT, to be launched in 2021, will develop technologies enabling the migration of many AI applications from power-hungry platforms to more sustainable solutions at the edge of the network, including the next generation of low-power processors for AI applications;
- ensure that the **environmental dimension** is included in Digital Europe actions that seek to make AI applications broadly available to potential users across Europe:
  - with projects starting in 2022, support TEFs for AI applications in the area of smart and green communities, manufacturing, energy and agri-food, directly contributing to environmental sustainability in these sectors, and AI applications at the edge of the network; and
  - facilitate the broad **deployment of AI competences through the EDIH netwo**rk, which will also reach SMEs and public administrations, enabling them to experiment with the use of AI for sustainability;
- create **a data space for climate-neutral and smart communities** and validate through pilots focusing on European Green Deal action areas (call in Q2 2021, results will be available Q3 2022);
- **develop a roadmap for a common European Green Deal data space** to exploit the major potential of data for sustainability and climate adaptation (call in Q2 2021)[177];
- **develop a high-quality, AI-supported digital simulation of the planet through the** 'Destination Earth' initiative[178] to monitor and simulate natural and human activity, and develop and test scenarios enabling more sustainable development and climate resilience[179]. Development starts in Q3 2021 and the first phase will be completed by end of 2023;

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177 Under the Digital Europe programme. For details on European data spaces, see Chapter 2 and the European Commission, *A European Strategy for Data*, February 2020.

178 Destination Earth will widely use Copernicus data assets provided by the Sentinel Satellites and Copernicus Services products. The AI solutions developed by Destination Earth will in turn contribute to improve the Copernicus programme.

179 The digital twins will give expert and non-expert users tailored access to high-quality information, services, models, scenarios, forecasts and visualisations (e.g. modelling of climate change adaptation strategies and scenarios for disaster risk management in relation to extreme weather-driven and geophysical events). A federated cloud-based modelling and simulation platform will provide access to data, advanced computing infrastructure, software, AI applications and analytics. See European Commission, *Destination Earth (DestinE)* information webpage.

- **strengthen sectoral dialogue on green AI** with executive leaders of European companies and other relevant stakeholders active in different sectors of the economy to identify specific actions needed in each sector for the sustainable deployment of AI benefiting the economy, society and the environment. Associations representing industrial sectors will contribute to the exercise[180];
- explore effective ways of **defining key performance indicators to identify and measure the negative and positive environmental impact of AI**, also building on the Commission's ongoing work on resource and energy efficient and sustainable infrastructure for data storage and processing [181], electronic communications and previous wider efforts in this field[182]. This could take place, i.e. through establishing a task force that would also assess the possibility of including an environmental score in the criteria for evaluating AI systems (e.g. in the context of public procurement); and
- **include environmental questions** in its **international coordination and cooperation** on AI. While AI can play a significant role in addressing challenges of planetary scale such as climate change and microplastics pollution, this requires coordination in the context of international organisations and possibly direct collaboration with like-minded countries.

Member States are encouraged to:

- **share results from national efforts** on 'green AI' **and climate actions**, share best practices with other Member States and, on the basis of their experiences suggest cross-border projects, outreach efforts and action that could be taken at European level;
- **share locally available expertise and know-how** through the EDIH network which can support training and knowledge-sharing activities;
- support the inclusion of a 'green AI' component in **university and higher education** AI curricula and other AI training courses and programmes; and
- work with national ICT and other sectoral stakeholders, including standardisation bodies towards defining **deployment guidelines and standardised assessment methodologies** to support 'green AI' in areas such as smart grids, precision farming, and smart and sustainable cities as well as communities.

12. Use the next generation of AI to improve health

Reasons for joint actions:

Globally, the EU is among the leaders in the application of AI in health and healthcare[183]. The area has seen rapid developments due to the increasing availability of health data, combined with unprecedented advances in AI. AI technologies can, for example, ease the burden on healthcare systems, improve hospital workflows, optimise the assignment of human and other resources, enhance the efficiency and effectiveness of clinical trials, and support the discovery of new medicines. AI systems can also support humans in clinical decisions and treatment choices[184], improve analysis of health images, laboratory or histological data, diagnostic

180 The AI, Data and Robotics PPP (see Chapter 4) will also provide input to strengthen sectoral dialogue on AI as part of its contribution to the Green Deal.

181 See European Commission, Green public procurement and Green public Procurement criteria for Data centres, server rooms and cloud services, information webpages, 2020.

182 E.g. activities by International Telecommunication Union *(International standards for an AI-enabled future*, 2020).

183 For a detailed analysis, see De Nigris S. et.al, 'AI uptake in health and Healthcare, 2020', JRC AI Watch Technical Report, 2020.

184 AI can unlock data insights to support diagnostics and treatments, but a human clinician should always make the final choices (human oversight).

accuracy, and access to healthcare[185], thus providing significant societal benefits. The social and economic importance of AI applications in health policy is recognised and strongly underlined at the EU policy level[186].

The COVID-19 pandemic has further reinforced the importance of AI for health and care and provided lessons for the EU and the Member States on the benefits of further cooperation in the field.[187] AI has been a major asset in the response to the pandemic. The Commission has invested *inter alia* in the rapid development of an AI chest computerised tomography (CT) analysis tool, supercomputing experiments to identify new therapies for COVID-19 and the dispatch of UV disinfection robots to tackle the spread of the coronavirus[188].

The availability of high-quality health data and the possibility of using, combining and re-using data from various sources in line with the EU acquis, including the GDPR and Union's international commitments, are essential prerequisites for the development and deployment of AI systems[189]. Accordingly, the Commission proposed[190] and in 2020 took preparatory actions for the establishment of a **European health data space (EHDS)**[191]. The Commission is currently working on a legal proposal on the EHDS[192]. Action will be taken to: address issues relating to governance, security, data protection and privacy, quality, infrastructures and the interoperability of data, digital health and AI, ensure the secure free flow of health data and promote the uptake of digital health and AI in health. The work strands include the establishment of an appropriate legal and governance framework for the EHDS, the deployment of EU-wide infrastructure for the exchange of and access to health data for research, policymaking and regulatory activities, the extension of the existing infrastructure for the exchange of health data for healthcare provision (MyHealth@EU), the improvement of data quality in the health sector and capacity building. The data space will encourage the upscale and uptake of digital health solutions including AI in healthcare, thus providing concrete benefits to patients. EHDS will support training and testing of AI algorithms.

On 25 November 2020, the Commission published a Communication on a Pharmaceutical Strategy for Europe[193]. The strategy is a key pillar of the Commission's vision to build a stronger European Health Union[194] and to foster patient access to innovative and affordable medicines[195].

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185 AI systems empower patients to monitor their health and improve access to healthcare, also in remote or low-resource areas. Human 'digital twins', (i.e. up-to-date, personalised models that mirror target aspects of the physiology, function, behaviour, etc. of a human being) can improve prevention, early diagnosis and effective treatment of diseases.

186 E.g. in the Commission Communication accompanying the Declaration of Cooperation on AI (10 April 2018), the White Paper on AI, the Ethics Guidelines for Trustworthy AI (8 April 2019) and the 2018 Coordinated Plan.

187 AI tools are also used to improve surveillance and care; for an overview of the projects supported by the Commission see the digital health technologies addressing the pandemic, information webpage (2020).

188 AI systems have been leveraged to tackle various aspects of the pandemic, e.g. the flagship Exscalate4CoV project aims to fast track the development of new COVID-19 therapies. See the Commission's webpage on actions in response to coronavirus pandemic: data, artificial intelligence and supercomputers.

189 Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (OJ L 119, 4.5.2016, p. 1).

190 The von der Leyen Commission's priorities for 2019-2024.

191 For the aims and steps taken, see Commission information webpage on the European health data space.

192 The Commission Roadmap, Digital health data and services – the European health data space, 2020.

193 European Commission, Pharmaceutical Strategy for Europe, 2020.

194 European Health Union package: COM(2020) 724, COM(2020) 725, COM(2020) 726, COM(2020) 727.

195 Digital transformation is affecting the discovery, development, manufacture, evidence generation, assessment, supply and use of medicines. These include systems based on artificial intelligence for prevention, diagnosis, better treatment, therapeutic monitoring and data for personalised medicines and other healthcare applications.

The Commission supports cooperation among Member States through the joint action on the European health data space, which formally started in early 2021. It supports national investments through funding instruments such as the European Social Fund+, InvestEU and the RRF. European-level actions are or will be supported through the EU4Health programme, Digital Europe and Horizon Europe.

The Commission and the Member States are cooperating to implement the Europe's Beating Cancer Plan[196]. It includes a number of actions where AI will be instrumental in strengthening cancer care, including the development of a common **health-image database** of the most common forms of cancer in order to improve AI-assisted diagnosis and treatment. To support this initiative, in 2019 the Commission launched a Horizon 2020 call for proposals with EUR 35 million available to support the development of health-image analysis for AI-based cancer diagnostics and treatment[197].

The Commission also looks at AI advances in relation to medical devices, in vitro diagnostic medical devices, pharmaceuticals and to improve the evidence base for decisions to identify potentials and address emerging challenges. Additionally, the Commission explores the introduction of AI in daily clinical practice and in diverse healthcare settings to also identify potentials and to address emerging challenges. Benchmarks and good examples are needed for data collection and for the development and testing of AI systems that ensure the protection of personal data and privacy in compliance with the GDPR and national legislation.

Outlook

The Commission together with Member States will:

- propose legislative action on a **European health data space**. This legislation action will complement the proposed AI horizontal legislation and would aim to support the training and testing of AI algorithms, as well as the work of regulators to evaluate the AI used in health (Q4 2021)[198];
- support collaborative projects bringing together stakeholders to take forward the use of high performance computing and AI in combination with EU health data for pharmaceutical innovation, as provided in the Pharmaceutical Strategy for Europe COM (the roll out of the projects 2021-2022);
- evaluate and revise the general pharmaceutical legislation to adapt to cutting-edge products, scientific developments (e.g. genomics or personalised medicine) and technological transformation, including AI (e.g. data analytics and digital tools) and provide tailored incentives for innovation, as envisioned in the Pharmaceutical Strategy for Europe (2022)[199];
- set-up TEFs in **Health for AI and robotics technologies** by 2022 through the Digital Europe programme, with the possible focus areas including COVID-19, cancer, paediatrics, active and assisted living technologies, support for patient safety, and process efficiency;
- take actions to expand the geographical coverage and the **cross-border exchange of health information**, through MyHealth@EU, including patient summaries, ePrescriptions, images, laboratory results and discharge letters, as well as actions to support the re-use of health data for research, policymaking and regulatory activities.

196 https://ec.europa.eu/commission/presscorner/detail/en/IP_21_342

197 Four projects were selected and started under this call in 2020 (ProCAncer-I, CHAIMELEON, EuCanImage and INCISIVE).

198 For details on the planned initiative see Digital health data and services – the European health data space, 2020.

199 European Commission, Evaluation and revision of the general pharmaceutical legislation, 2021.

Those actions will be funded through the EU4Health programme[200], DEP and Horizon Europe programmes with the goal by 2025 to ensure that:

  - citizens from all the Member States are able to share their health data with healthcare providers and authorities of their choice;
  - an EU-wide infrastructure of the EHDS for accessing health data for research and policymaking is set up. AI will be an important part of the EHDS and will allow for data analytics, supporting and accelerating the research;

- continue to support the deployment of the infrastructure needed to link and explore European **databases,** for example **of medical images**, of different types of cancer, and leverage AI technologies to exploit high-quality cancer imaging repositories;
- facilitate the use of AI technologies, in full compliance with data protection legislation, ethical principles and competition rules to identify new knowledge and support clinical research and decision-making in the **'1+ million genomes' initiative**. This initiatives builds on the Member States' '1+ million genomes' declaration and aims to make at least 1 million genomes accessible for research in the EU;
- support the development and deployment of applications of the '**digital twin in health and care'**, where AI technologies will have a central role, through the promotion of a functional, inclusive EU system; and
- invest in the development and clinical validation of robust, fair and trustworthy demand-driven AI-powered systems for treatment and care, under Horizon Europe, including personalised prevention and risk prediction of diseases, with a particular focus on performance, safety, security, explainability, provision of feedback and support on fraud prevention in healthcare, usability and (cost-) effectiveness of AI solutions, and the use/re-use of unstructured health data.

Member States are encouraged to:

- take actions to **increase the quality and semantic interoperability of health data**, which is fundamental for the development and use of AI;
- develop actions and support initiatives to increase medical professionals' **understanding and acceptance of digital technology** to accelerate adoption of AI-based systems in the medical field;
- implement recommendations that promote the **eHealth upskilling of healthcare workers** and agree on common European quality indicators for continued medical education;
- advance the **'1+ million genomes'** initiative possibly through their national recovery and resilience plans, including as a multi-country project;
- support investments in secondary use of health data, including for AI, using, for example, RRF funding;
- take action to facilitate the **integration of innovative AI-based systems** (e.g. machine learning, autonomous systems, conversational agents, big data, robotics) in health and care facilities such as hospitals and care homes, and notably when the digitalisation of the health systems has been outlined in the national recovery and resilience plans;

[200] EU4Health 2021-2027 – a vision for a healthier European Union.

- support **EDIHs specialised in medical technologies and eHealth** in order to help regional/national health systems and industry in their research efforts to provide better treatments and advances towards beating the coronavirus; and
- work with national, regional and international standardisation bodies to formulate towards defining and setting **common standards**, including on issues such as security, safety, privacy, interoperability, in an effort to update existing standards for AI for health.

13. Maintain Europe's lead: Strategy for Robotics in the world of AI

Reasons for joint actions:

Robotics powered by AI is a key enabler for the EU's productivity, competitiveness, resilience and open strategic autonomy while preserving an open economy in the digitalising world.[201] Robotics is progressing rapidly and AI-enabled robots are increasingly deployed with significant impact in many key sectors, such as healthcare, agri-food, inspection and maintenance, logistics, space, construction, manufacturing, etc. The adoption of AI-based robotics will fuel developments in the EU robotics industry and expand the range of activities in which robots operate, increasing human-robot collaboration[202].

The **impact of COVID-19** on the global economy has shown the need for more resilient supply chains. Robotics automation has the potential to re-shore some production to Europe and to increase its autonomy in critical value chains. Robotics is expected increasingly to support workers in various ways and to improve working conditions. **Demographic challenges** in Europe will increase the need for robots and automation[203], especially in the service sector (in particular healthcare and independent living for the elderly).

In sum, robotics are set to bring major benefits to society, the economy, the environment and the public at large.

This development comes with a number of challenges. The changing labour landscape stresses the need to devise new working methods and to develop appropriate training in skills and competences for work alongside robots, and to understand their capabilities and limitations. Left unaddressed, these factors undermine trust in and acceptance of robotic technology. The Commission will continue to closely monitor the impacts on society, employment and labour conditions in the light of the development and uptake of AI technologies.

On the other hand, the specificity of robotics is linked to physical interaction with people and the environment. Robots will be increasingly autonomous and interacting with humans, be it co-working robots emerging from cages or robots providing services. This raises questions of safety: proximity to humans and interaction with them requires very high safety standards to prevent accidents and injuries. It also raises issues regarding ensuring accessibility and inclusiveness of persons with disabilities. Robots are also becoming more and more connected to each other and other types of devices and process more data, posing potential privacy and cybersecurity risks. All these considerations highlight the need to address testing, as planned in the future Testing and Experimentation Facilities, and to deal with issues such as

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201 On the concept of open strategic autonomy see Section 2.1 of the Commission Communication on an 'Open, Sustainable and Assertive Trade Policy'.

202 Robotics will support increased efficiency, optimisation, quality and sustainability, in both industry and services. Cf. Duch-Brown, N and Rossetti, F (2021) Evolution of the EU market share of robotics: data and methodology. JRC Technical Report.

203 The share of European population older than 65 will increase from 20 % in 2018 to 31 % in 2100. For details, see Eurostat information webpage.

certification and compliance with the regulatory framework, e.g. through regulatory sandboxes.

Consequently, robotics is a policy area with a large potential of economic and social impact, including key areas to support Europe's green and digital transition.

Europe is well placed to realise the potential and to address the challenges. **Europe has a leading robotics industry and research community**: it is home to many robot manufacturers, which produce about a quarter of all industrial robots and service robots. In some areas of professional service robotics, such as milking robots, European manufacturers dominate the market. Europe is also leading in robotics research, with demonstrated impacts in many use-cases in key sectors (e.g. healthcare, agriculture, inspection, marine, manufacturing). Developments in industrial and service robotics are converging and reinforcing each other. This offers European developers a unique opportunity to strengthen their capabilities and market outlook.

Nevertheless, to maintain and consolidate Europe's strong position and to fully capitalise on its assets, intellectual and financial investments are needed, as well as collaboration across a wide spectrum of public and private players. Also, Europe's action on robotics must capitalise on the latest AI developments to address innovation and standardisation, issues of trust, skills shortages and impact on jobs and on the environment, in order to enable the roll out of safe, secure and trustworthy robotics solutions.

Outlook

The Commission will:

- in the context of this Coordinated Plan, implement actions to ensure that Europe remains a global powerhouse in robotics. Action includes research, innovation and deployment elements[204], as well as important aspects related to safety and security, testing and validation, socioeconomic issues, skills and competencies, and trust and ethics. It builds on and further develops the strategic approach taken by past and existing initiatives, especially the Public-Private Partnership in Robotics under Horizon 2020 and the new co-programmed European Partnership in AI, Data and Robotics under Horizon Europe;
- building on information from existing structures as well as other relevant policy initiatives at EU and national levels[205], and to further complement them when necessary, evaluate and if deemed necessary, develop a specialised robotics policy observatory to monitor and support the implementation of the robotics strategy, in measuring progress and supporting coordination and cooperation;
- starting in 2021, conduct a review of possible regulatory obstacles and support certification that will enable development and uptake of robotics solutions;
- test the expected performance and **safety of AI-powered robots** through dedicated world-class TEFs under the Digital Europe programme, to be built from 2022 onwards. The TEFs should also contribute to conformity assessment procedures and the development of standardisation activities in this field;

[204] Zillner, S., et.al. Strategic Research, Innovation and Deployment Agenda, AI, Data and Robotics Partnership. Third release', September 2020. BDVA, euRobotics, ELLIS, EurAI and CLAIRE.

[205] European Commission, Communication, Action Plan on Synergies between civil, defence and space industries EU (COM(2021) 70 final). The action plan provides that 'The Commission will set up within its services an EU Observatory of Critical Technologies'.

- further support the development of robotics solutions and from 2022 their deployment with TEFs that contribute to the **Green Deal,** also focusing on other societal challenges such as health and human well-being;
- support robotics research and innovation in Europe with the co-programmed European Partnership in AI, Data and Robotics, building on past successes with previous partnerships[206]. This public-private partnership, set to start in Q2, 2021, will also have a specific focus on standardisation in order to foster collaboration between stakeholders within the robotics ecosystem;
- leverage its dedicated **network of EDIHs** to support the European robotics sector and stakeholders, and to boost adoption;
- include robotics among the subjects targeted in the ambitious strategy for advanced digital skills under the Digital Europe programme, namely by supporting specialised robotics education programmes or modules, job placements and short-term robotics training courses, starting in 2022;
- support research and innovation towards the **next generation of AI-powered Robotics** through Horizon Europe projects, starting in 2022. The initiatives should focus, among other things, on making robots more collaborative and endowed with a better 'understanding' of the world, thus ensuring safety, energy efficiency and robustness, e.g. to operate under extreme physical conditions; and
- support the **exchange of knowledge, practice and experience** in robotics, e.g. for use-cases in specific sectors or specific types of robot (unmanned aerial vehicles, etc.).

The Commission and Member States will:

- work together to analyse relevant AI and robotics initiatives at EU and national levels, identifying possible gaps, priorities and policy metrics;
- work with national, regional and international standardisation bodies towards defining common standards, including on issues such as safety, security, interoperability, multi-agent systems or shared and sliding autonomy, in an effort to update existing standards for smart robotics; and
- promote robotics in education for all age-, gender and social groups, to raise awareness and trust, including the use of robotics as tools to support learning and training, in line with the initiatives in the skills and talent section.

Member States are encouraged to:

- develop **national investment plans for robotics** within their respective AI strategies, building upon the European strategy and with strong participation of national stakeholders, with a focus on research and innovation as well as making use of the Recovery and Resilience Facility to support the digital transition.

14. Make the public sector a trailblazer for using AI

This section focuses on measures that support the uptake of AI technologies in the public sector.

206 See Chapter 4.

Overview of actions taken

AI applications can contribute to better **public services,** e.g. by improving citizen-government interaction, enabling smarter analytical capabilities or improving efficiency across public-sector domains and supporting democratic processes[207]. Use of AI systems can bring benefits across all key public-sector activities. Through early adoption of AI, the public sector can be the first mover in adopting AI that is secure, trustworthy and sustainable[208].

For deeper and wider AI uptake to become a reality, Europe's public sector should have access to adequate funding and be equipped, skilled and empowered to conduct strategic and sustainable purchasing and adoption of AI-based systems. **The RRF provides an unprecedented opportunity to accelerate the uptake of AI in public administration** across Europe through its Modernise flagship which aims at boosting investments and reforms in digitalisation of public administration.

Public procurement is key in public sector AI adoption. It can also help stimulate demand and offer of trustworthy and secure AI technologies in Europe. In this context, the Commission is developing an **Adopt AI programme**[209] to support public procurement of AI systems and help to transform public procurement processes themselves. The programme aims to help Europe's public sector to use its strong collective purchasing power to act as a catalyst and stimulate demand for trustworthy AI. The public sector can lead the way in developing, purchasing and deploying taking in use trustworthy and human-centric AI applications, for example, by utilising public procurement of innovative solutions or by steering the development of new solutions towards its needs through pre-commercial procurement practices.

Almost all Member States' national AI strategies include actions to stimulate the use of AI in public services[210]. Currently, more than half of the AI solutions in use provide incremental or technical changes to public-sector processes[211]. The Member States and the Commission have started to engage in peer-learning and EU-wide exchange of best practices on public sector AI[212].

Collaborative cross-border public procurements or pre-commercial procurements of innovative AI solutions have the potential to exploit synergies and achieve higher critical mass in bringing AI solutions to the public sector market across Europe. There is an opportunity for shared European action in procuring, bringing taking into use and scaling up AI solutions among Member States.

For instance, the **Commission's AI-powered eTranslation portal was introduced to public administrations in Member States in November 2018**[213]. Two years later, 6 600 civil servants across the Member States are utilising the eTranslation web portal. National authorities can request direct access to the web service, which is currently used by around 50 administrations, including the Swedish National Data Portal, the Italian Chamber of Deputies

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207 AI can support democratic processes, for example, by improving decision-making processes, data analysis or citizen participation and engagement. For examples on citizen participation see Savaget, P., Chiarini, T., and Evans, S, Empowering political participation through artificial intelligence. Science and Public Policy, 46(3), 2019.

208 See Chapter 9 for public sector action on sustainable AI.

209 As proposed in the White Paper on AI.

210 JRC AI Watch Report on National AI Strategies (forthcoming 2021).

211 Misuraca, G. and Van Noordt, C., AI Watch – Artificial intelligence in public services, JRC Science for Policy Report (2020).

212 A joint project with JRC through the AI Watch study. The study will also produce an overview of relevant applications already in place in Member States and help in understanding impact and added value in support of public service delivery.

213 For details, see Connecting Europe eTranslation platform.

or social-security institutions[214]. The Commission has also engaged in AI-related actions, for instance in ISA²[215], including a pilot to tackle the use of machine learning for document review/classification in administrations[216]. Other initiatives included, for example, analysis of the use of AI in the justice field[217] and the organisation of practical AI webinars on the use of AI applications in that area[218].

Outlook

The Commission will:

- launch in 2021 the **Adopt AI programme**, as announced in the White Paper to support public procurement of AI systems and help transform public procurement processes themselves[219]; in particular:
  - **open** and **transparent sectoral dialogues** will help to build a bridge between public procurers (who want to know what solutions are available to address their needs) and European industry (which wants to supply products/services to public administrations and which needs to know more about their plans)[220];
  - this will be organised on a European scale, allowing Member States to learn from each other. EDIHs will be used to promote dialogue among industry actors throughout Europe[221]. The programme will thus stimulate industry investment in AI and the development of new AI technologies and applications;
- design in 2021 a **public procurement data space**[222] that will provide a comprehensive overview of public procurement markets in the EU[223]. A future IT tool will facilitate the use of AI methods to analyse public procurement data. Available data combined with updated, powerful analysis tools will be central to improving the governance of public procurement; and
- continue to facilitate Member State peer-learning and information-gathering on guidelines and the implementation of AI in public services, based on best practices and analysis of the re-use potential of AI-based systems and solutions, identifying opportunities for collaboration among relevant stakeholders from various sectors[224].

With the support of the Member States, the Commission will:

- fund through the Digital Europe programme, initiatives for the adoption of AI by the public administrations at local level, through the reinforcement of European capacity for

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214 In March 2020, the web portal was also made available to SMEs; there are already almost as many SMEs among the users as public administrations.

215 See European Commission ISA² webpage – Bringing new technologies in the public sector – AI related actions in ISA² programme (Interoperability solutions for public administrations, businesses and citizens) (2018).

216 See European Commission, Innovative public services action information webpage (2018).

217 European Commission, Study on the use of innovative technologies in the justice field, September 2020.

218 The webinars are organised pursuant to the 2 December 2020 Communication on the digitalisation of justice in the EU (COM(2020) 710 final).

219 See White Paper on AI.

220 The Adopt AI programme will build such a bridge by organising events and opportunities for supply and demand to come together. Instruments such as dialogues, hackathons and pre-commercial procurement will enable suppliers to respond better to procurement requests, and public authorities to understand the market better and formulate targeted procurements.

221 In line with Article 40 of the Public Procurement Directive (2014/24/EU), public buyers will publish prior information notices on the Tenders Electronic Daily (TED) portal to launch EU-wide, transparent, non-discriminatory preliminary market consultations.

222 See European Commission, A European strategy for data, (COM(2020) 66 final).

223 EU-level data (procurement award notices on TED) and Member States' open datasets.

224 Expected outcome of the ongoing AI Watch work on the public sector AI adoption.

the deployment and scale-up of AI-powered Local Digital Twins[225] (call in Q4 2021, project to start in Q3 2022);

– support public administrations, including cities and communities in creating AI algorithm registries to increase citizen trust, and encourage the use of catalogues of AI-enabled applications for administrations to increase the take-up of AI by the public sector, for example through the AI-on-demand platform (call in Q4 2021, project to start in Q3 2022); and

– continue to support public administrations including cities and communities in procuring trustworthy AI by developing a set of minimal capabilities for algorithms to be used in contract conditions (e.g. Fair AI MIM)[226] through the Living-in.EU movement[227] and by other means. The minimal capabilities could include APIs for disclosing levels of automated decision-making.

Member States are encouraged to:

– take full advantage of the opportunities offered by RRF by including in their national recovery and resilience plans measures focusing (for example) on building capacity to seize the advantages of predictive analytics and AI in policymaking and public service delivery. The proposed reforms and investments under this component champion the RRF Flagship 'Modernise' focusing on digitalisation of public administration and services, including judicial and healthcare systems. They might also mirror the objectives of the RRF Flagship 'Reskill and upskill', by providing skills and new competences for civil servants and managers, notably in relation to green and digital transitions and to enhancing innovation in public administration.

15. Apply AI to law enforcement, migration and asylum

Reasons for joint actions:

AI systems, if designed and used in accordance with democratic principles and fundamental rights, can become central technology to support (but not replace)[228] home affairs authorities and strengthen security. In particular, law enforcement authorities should be able to act in a rapidly changing and evolving criminal landscape to **enhance the protection and safety of all persons**[229]. AI can also improve cybersecurity, for example by assisting in threat intelligence, through the recognition of patterns based on past experience, by reducing incident response times and facilitating compliance with security best practices.

Member States are increasingly using AI systems in the field of home affairs[230] as they have proven to be very useful in enhancing public order, supporting accurate decision-making, and

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225 Local digital twins are a virtual representation of a city's physical assets connected to data. These digital twins may focus on extreme weather events, urban planning or crisis management. Machine learning can be used to help a city operate more efficiently, by creating simulations, models or carry out real-time monitoring. European Commission, Workshop Report: Digital Twins of cities, 2020.

226 'Open and agile smart cities (OASC)', MIM 5: Fair AI and Algorithms (2020).

227 'Join, boost, sustain— the European way of digital transformation in cities and communities'; for details, see the Living-in.EU movement information webpage.

228 Considering the importance of the policy area and the need to ensure protection of fundamental rights, law enforcement, migration and asylum AI applications are never used as a self-standing 'decision-maker'. AI systems are used to assist, for example, by providing clues for investigation or assessment in a concrete context, but a human always takes the final decision.

229 On the use of AI applications in the field of home affairs in Member States, see, e.g. Joint Research Centre, Artificial Intelligence in public services, JRC (2020).

230 Artificial intelligence in public services, JRC (2020) suggests that 11 Member States are using 25 AI applications in the field of home affairs.

fighting crime and terrorism[231]. Stronger cooperation on the development and deployment of AI technologies in the area of home affairs is essential. By joining forces, and in full compliance with fundamental rights, Member States' law enforcement and other authorities can address more effectively the new challenges posed by the immense quantity of data, ever more sophisticated and complex criminal activity, and the use of AI by criminal organisations, in particular in cybercrime[232], as well as the increasing requirements for smooth, quick and user-friendly procedures. Accordingly, Member States reiterated as one of the political priorities and stressed as an important milestone to support the functioning of the area of freedom, security and justice, that law enforcement authorities are able to use AI technologies in their daily work, subject to clear safeguards [233]. Member States have called on the Commission to promote the creation of an AI talent pool and facilitate the development of training opportunities in digital literacy and skills for law enforcement[234].

On 9 December 2020, the Commission adopted an **EU counter-terrorism agenda**[235] which underlined the profound impact of AI on the ability of law enforcement authorities to respond to terrorist threats in line with fundamental rights and freedoms. Also in 2020, Member States and the EU set up the EU innovation hub for internal security that also focuses on AI tools[236] to serve as a collaborative network. The Commission further adopted a proposal on the strengthened mandate of Europol to enable the Agency to address emerging threats, allowing it to cooperate effectively with private parties and enhancing its role on innovation[237]. Europol should play a key role in: (1) assisting Member States to develop new technological solutions based on AI, which would benefit national law enforcement authorities throughout the Union and (2) promoting ethical, trustworthy and human-centric AI subject to robust safeguards in terms of security, safety and fundamental rights[238]. On 14 April 2021 the Commission also presented a new EU Strategy to tackle Organised Crime, which aims at ensuring a modern response to technological developments, including the use of AI in criminal investigations, such as for the analysis of large quantities of data or for darknet investigations[239].

Moreover, to address the specific challenges in the area of home affairs including the capability to respond to crimes committed or facilitated by the use of AI technologies, the Commission has developed sector-specific work strands for law enforcement, migration and

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231 E.g. AI technologies are used for data analytics; augmented and virtual reality to model public safety in mass events, the automated detection of cyberthreats, search and rescue operations with drones and robotics, the screening of travellers and the facilitation of asylum applications (virtual assistants and translation programs).

232 Joint report of Europol, UNICRI and Trend Micro on 'Malicious uses and abuses of Artificial Intelligence' published on 19 November (https://www.europol.europa.eu/publications-documents/malicious-uses-and-abuses-of-artificial-intelligence).

233 Council Conclusions on internal security and European police partnership (2020).

234 Council Conclusions on internal security and European police partnership (2020).

235 European Commission Communication, A Counter-Terrorism Agenda for the EU: Anticipate, Prevent, Protect, Respond (COM(2020) 795 final). See also, joint report of Europol, UNICRI and Trend Micro, Malicious uses and abuses of Artificial Intelligence, 2021.

236 As requested by the Council, the Hub will provide primarily a coordination mechanism between the EU's police (Europol), border force (Frontex) and home affairs IT systems (eu-LISA) agencies and the Commission. The Steering Group will be chaired by a Member State representative nominated by COSI for a period of 3 years and a representative of the European Commission (DG HOME). The aim of the Hub is to support the participating entities in the sharing of information and knowledge, the setting up of joint projects, and the dissemination of findings and technological solutions developed, as announced in the EU Security Union Strategy. See also: https://data.consilium.europa.eu/doc/document/ST-5757-2020-INIT/en/pdf

237 Commission Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 2016/794, as regards Europol's cooperation with private parties, the processing of personal data by Europol in support of criminal investigations, and Europol's role on research and innovation (COM(2020) 796 final).

238 Commission Proposal COM(2020) 796 final, recital 38.

239 European Commission, Communication on the EU Strategy to tackle Organised Crime 2021-2025 (COM(2021)170 final

asylum.[240] The EU coordination efforts in this policy area focus on increasing the efficiency of the competent authorities by pooling resources and expertise, exchanging best practices and adjusting the legal framework, where necessary. This also serves the objective that AI-enabled technologies fully comply with democratic values, the rule of law and fundamental rights and principles, including non-discrimination and data protection. These efforts will also contribute to the establishment of an ecosystem of trust.

Outlook

In order to enhance transparency, explicability and public trust **the Commission** will:

- launch a call for a dedicated common European **security data space** for law enforcement under the Digital Europe programme[241] (Q1 2022). This will be an individual data space which falls under the broader Common European data spaces for public administrations as announced in the European Strategy for Data;
- in 2021 assess the feasibility of a **data management and data science framework** at EU level for law enforcement; in order to enhance the transparency and explicability of AI-driven data analysis[242];
- in Q1 2021 fund the UN Interregional Crime and Justice Research Institute project, to develop a **global toolkit** for law enforcement agencies with a view to fostering the trustworthy, lawful and responsible use of AI for law enforcement (as described in the amended 2020 work programme of the Internal Security Fund);
- continue launching 'proofs-of-concept' in 2021 for concrete use-cases of AI in the field of **regular border control, migration and police checks**[243];
- in 2021 launch a pilot for a single European **migration forecasting system** based upon the outcome of the study on the feasibility of a forecasting and early-warning tool for migration based upon AI technology [244]; and
- continue funding research and innovation on AI for application and knowledge base for law enforcement, migration and asylum that are European-based and fully respect fundamental rights and EU values.

The Commission, Member States and the relevant EU agencies will:

- work together in the context of the EU innovation hub for internal security;
- cooperate on AI applications as a useful facilitator for supporting and improving the effectiveness of the asylum procedures; and
- take actions to support enforcement of environmental law and combat environmental crime with the help of AI technologies.[245]

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240 Follow-up of 'Migration 4.0: The Digital Transformation of Migration Management', launched under the German Presidency.

241 This initiative will allow research, development, testing, training and validation of algorithms for AI-based systems for law enforcement and security agencies based on various different types of dataset, including pseudo-operational and anonymised datasets.

242 This action was announced on 17 December 2020 in the AI expert group for home affairs.

243 This initiative is based on the *Opportunities and challenges for the use of artificial intelligence in border control, migration and security* report (2020). This action was announced by the Commission in the Interoperability Forum on 28 October 2020. The first proof of concept was launched on 19 July 2020 and completed in December 2020. The study pointed at possible AI applications, some of which will be piloted in 2021 as a proof of concept.

244 European Commission, *Feasibility study on a forecasting and early warning tool for migration based on artificial intelligence technology*, 2021.

16. Make mobility smarter, safer and more sustainable through AI

Reasons for joint actions:

AI and automation and are of key importance for the mobility of the future. They can help improve transport efficiency and safety, optimise capacity use and traffic flows, and facilitate technology and language interoperability. AI can optimise multimodal transport chains and allow for the operation of automated vehicles. With growing data availability and AI-assisted tools for analysis, AI will facilitate new, safer, more inclusive, sustainable, and more efficient passenger and freight transport and mobility services. In order to ensure truly inclusive transport and mobility services, datasets used to train AI algorithms must be representative and balanced to avoid unintended results and potential discrimination of certain transport users.

At an informal Council on 29 October 2020, **EU transport ministers** underlined the importance of proactive cooperation with the EU institutions and of joining forces 'to ensure that Europe exploits the opportunities inherent in the digital revolution for future-proof mobility, a powerful economy with secure, attractive jobs and a liveable climate-neutral future'[246].

In December 2020, the Commission adopted its **sustainable and smart mobility strategy**[247], which provides (among other things) for the development of an AI roadmap for mobility[248], and the development of a common European mobility data space, as announced in its European Data Strategy published in February 2020.

AI technologies impact all modes of transport and the EU has already developed initiatives[249] to benefit from its potential:

- in the **aviation sector**, in February 2020, the European Union Aviation Safety Agency (EASA) published an AI roadmap. Eurocontrol together with the European Commission and a wide range of partner organisations set up a European Aviation High Level Group on AI (the EAAI HLG) that in March 2020 published a FLY AI Action Plan[250]. Furthermore, the EASA runs a project 'Data4Safety' that establishes a big pool of data that may support the management of safety risks at European level[251];
- in the **rail sector**, the Shift2Rail (S2R) Joint Undertaking currently works on the definition of automatic train operation specifications, including the use of AI, grade of automation 3 and 4. In addition, the use of AI is already considered in the context of

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245 See Digitalisation for the Benefit of the Environment - Council conclusions 17 December 2020 section on AI to advance environmental protection; Good practice document on combatting environmental crime, April 2020 on existing Member State projects; and CMS Legal publication Artificial Intelligence in environmental monitoring, August 2019.

246 Passau declaration of 29 October 2020 on a 'smart deal for mobility: shaping the mobility of the future with digitalisation — sustainable, safe, secure and efficient'. The declaration was drawn up by Member States and the Commission and signed by 30 EU and EFTA countries.

247 European Commission, Communication, Sustainable and Smart Mobility Strategy – putting European transport on track for the future (COM/2020/789 final).

248 Currently, the sector does not have a comprehensive roadmap that would allow it to unlock the full potential of AI (also beyond data issues) and manage related challenges in transport and logistics.

249 See Communication COM/2020/789 final.

250 Eurocontrol: Fly AI Report - Demystifying and Accelerating AI in Aviation/ATM, March 2020.

251 The data collected includes: flight safety data, aviation surveillance (air traffic control) data, weather and space-based data for common processing and intelligent data analysis with the purpose to analyse and improve aviation safety, security and environmental performance and safe operations.

Innovation Programmes of the S2R framework both for passengers and freight rail[252]. The use of AI will be embedded more and more in the successor of S2R, as digitalisation and automation will be key enablers of the rail transformation with a system approach;

- in the **inland waterway sector** the River Information Services enabled Corridor Management Execution (RIS COMEX) is a CEF funded multi-Beneficiary project[253]. Many of these RIS-based Corridor (information) services make use of Big Data and AI-based algorithms for calculating optimal routes, traffic densities and estimated times of arrival; and
- in the **road transport sector**, the work of the Cooperative, Connected and Automated Mobility (CCAM) Platform and of the upcoming European Partnership CCAM consider AI and the specific ethical issues raised by driverless mobility. The report by the European Commission expert group – Ethics of Connected and Automated Vehicles – provides recommendations on road safety, privacy, fairness, explainability and responsibility[254] [255].

Outlook

The European Commission with the support of the Member States will:

- develop in 2021 an **AI roadmap on mobility**, as announced in the sustainable and smart mobility strategy;
- develop in 2021 and onwards **actions and provide funding to support data availability, data processing technologies and capacities as well as data-sharing in data spaces through the Horizon Europe programme, the Digital Europe programme and the European Cloud Federation**. The availability and integrity of data are essential for the development of reliable AI algorithms that can improve transport safety and optimise traffic flows;
- collaborate and **facilitate actions on standardisation**, appropriate approval procedures and interoperability in the single market, to foster the quick implementation of automated functions; this will also boost international competitiveness;
- consider **measures to accelerate the implementation of innovative AI technologies in Europe's transport and mobility sectors**. In particular for CCAM technologies and systems, the co-programmed European Partnership CCAM, which will seek synergies with the co-programmed European Partnership on AI, Data and Robotics, and prepare for large-scale deployment. Other measures could study specific automotive requirements on functional safety and security; and adopt measures to facilitate trust and social acceptance of CCAM by enhancing transparency, safety and explainability of technology;

252 See S2R R&I Programme on the details of the Innovation Programmes. Specifically AI related are IP4 – IT solutions for Attractive Railway Services (e.g. My-Trac project), IP3 – Infrastructure (e.g. condition based maintenance of the infrastructure and robotics), IP2 – Traffic Management (e.g. capacity performance, ATO).

253 The project involves 13 countries and covers the definition, specification, implementation and sustainable operation of Corridor RIS Services.

254 Final report (2020).

255 Also study by ENISA and the Joint Research Centre highlighted the importance of cybersecurity in the update of AI technologies in autonomous vehicles and its potential implications for road security and safety: ENISA, Joint Research Centre, 'Cybersecurity Challenges in the Uptake of Artificial Intelligence in Autonomous Driving', 2021.

– in 2021 set out implementing acts for **technical specifications for automated vehicles and fully automated vehicles**, including safety issues linked to the use of AI and cybersecurity[256]; and

– in 2021, propose new rules on access to in-vehicle data, guaranteeing fair and effective access to vehicle data by mobility service providers.

Member States are encouraged to:

– actively promote the **development and testing of AI technologies in automated functions** for all modes of transport, with the help of the relevant European partnerships;

– analyse and facilitate the **deployment of trustworthy AI solutions in all modes of transport** that can enhance efficiency with the help of automated mobility services and freight transport operations in order to reduce the burden on the environment;

– share lessons learned from **R&I projects and pilots** to create a European common knowledge base;

– assess the **potential of vehicle automation for urban transport** and support cities in their transition while rethinking mobility systems, including public transport services, infrastructure maintenance, logistics, fares and regulation; and

– take full advantage of the opportunities offered by RRF, for instance in line with the actions described in the example of component on '**Clean, smart and fair urban mobility**'[257]. This example component champions the European Flagship 'Recharge and refuel' and promotes future-proof clean technologies to accelerate the use of sustainable, accessible and smart transport, zero and low emission vehicles, charging and refuelling stations, and stronger, more extensive public transport. This example component is also related to sufficient supplies of renewable electricity and hydrogen, in relation to the European Flagship 'Power Up'. Measures under this type of component could, for example, support the digitalisation of transport that will enable the emergence of innovative mobility-related businesses and services, such as capacity planning and traffic management systems. Smart mobility will benefit from but also contribute to 5G roll-out, the development of AI, block-chain, and other digital technologies.

17. Support AI for sustainable agriculture

Reasons for joint actions:

The EU agricultural sector is one of the world's leading producers of food, a guarantor of food security and quality and provider of millions of jobs for Europeans. AI and other digital technologies have the potential to increase farm efficiency while improving economic and environmental sustainability.

AI-powered solutions and robots can support farmers, for example, in livestock production and ensuring animal welfare[258], breeding[259], harvesting crops[260] or weeding[261], and

256 New rules on automated vehicles, cybersecurity and software updates of vehicles will become applicable as part of the vehicle type approval and market surveillance legislation as from 6 July 2022.

257 Example of component of reforms and investments – Clean, smart and fair urban mobility.

258 See, e.g. Horizon 2020 CYBELE project proposing scalable Big Data Analytics for precision agriculture and livestock farming as well as IoF 2020 project accelerating Internet of Things in the agri-food sector.

259 See, e.g. Horizon 2020 GenTORE project proposing genomic management tools to optimise resilience and efficiency.

260 See, e.g. Horizon 2020 BACCHUS project proposing a smart robotic system for automated harvesting in agriculture.

significantly reducing the use of inputs such as fertilisers, pesticides or irrigation water[262], thus leading to significant economic and societal benefits[263]. The availability of data, both generated by the increasing digitalisation of agriculture, as well as data from earth observation or climate data, is an important enabler for the acceleration and development of AI-based solutions. The economic values of the AI-enabled precision farming market is estimated to grow and reach EUR 11,8 billion by 2025 globally[264].

In 2019, the Commission worked with Member States on a declaration to promote a comprehensive approach towards digitalisation and to smart and sustainable agriculture, including through facilitation of use of AI. This declaration of cooperation, signed by 25 European countries, entails a commitment to facilitate the deployment of digital technologies, including AI, in agriculture and rural areas[265].

As part of the Green Deal agenda, in May 2020 the Commission put forward the 'farm to fork strategy'[266]. This strategy aims to facilitate sustainable food production and a transition of food chains in Europe that benefit consumers, producers, the climate and the environment. The use of AI and smart farming could facilitate this transition by enabling, for example, sustainable and efficient management of resources such as water, soil, biodiversity and energy.

In 2014-2020, the Commission co-funded Horizon 2020 research projects worth close to EUR 175 million to digitalise agriculture. The projects focused, e.g. on the sustainable use of resources by deploying digital technologies such as AI, robotics and the IoT.

Outlook

The Commission together with Member States will:

- set-up of **TEFs for AI for the agri-food sector under** the Digital Europe programme, with a particular focus on smart farming, e.g. to improve cost-effectiveness and environmental sustainability;
- promote agriculture as one of the areas covered by the **EDIH** initiative to support interactions between relevant actors, including Member States, agricultural stakeholders and players in the European AI system;
- implement a common European agriculture data space to support trustworthy pooling and sharing of data[267] in 2023-2024. The data space will allow participants to share agricultural data. It is expected to enable the agricultural sector to enhance its sustainability performance and competitiveness through the processing and analysis of production and other data, allowing for precise and tailored application of production approaches at farm level. Furthermore, it will consider the experience of the stakeholder-led Code of Conduct on agricultural data sharing[268];

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261 See, e.g. Horizon 2020 ROMI precision farming working on solutions that would reduce by 25 % the time that farmers to weed their fields.

262 See, e.g. Horizon 2020 PANTHEON project on precision farming of hazelnut orchards.

263 *Federating platforms: helping European agriculture to become more green, productive and competitive*, September 2020.

264 European Commission Sectoral Watch (2020), Technological trends of the agri-food industry, September 2020.

265 Declaration, A smart and sustainable digital future for European agriculture and rural areas, 2019; see also, e.g. EU Member States join forces on digitalisation for European agriculture and rural areas, April 2019.

266 European Commission, Communication, *A 'farm to fork' strategy for a fair, healthy and environmentally-friendly food system* (COM(2020) 81 final).

267 Under the Digital Europe programme, the Commission plans to support the deployment of technologies, processes and standards needed to operationalise such an agriculture data space, including private and public data (European Commission, A European strategy for data COM(2020) 66 final).

268 Code of conduct on agricultural data sharing by contractual agreement, COPA-COGECA and CEMA (2018).

- set up and actively contribute to a co-programmed European Partnership on **Agriculture of Data**[269] under Horizon Europe in 2023-2024. The partnership will seek to promote the use of AI, other digital technologies, and geospatial and other environmental observation data. Member States and relevant stakeholders from agriculture, research and industry, including the Copernicus programme and Earth observation community, will be closely involved; and
- support **R&I projects** under Horizon Europe that link AI and robotics technologies to their use in agriculture, forestry, rural development and the bioeconomy, maximising the use of data from the EU space infrastructures such as Copernicus.

Member States are encouraged to:

- take full advantage of RRF funding for the digitalisation of the agri-food sector, as envisaged in the national plans, for example to set up additional AI and robotics TEFs and EDIHs in agri-food, in addition to those already planned under the Digital Europe programme;
- take an active role in the partnership Agriculture of Data and;
- consider funding of national R&I projects that link AI and robotics technologies to their use in agriculture, forestry, rural development and bioeconomy.

CONCLUSIONS:

The objectives of the 2018 Coordinated Plan remain relevant and the overall direction set in the Coordinated Plan has proven to be the right one to contribute to Europe's ambition 'to become the world-leading region for developing and deploying cutting-edge, ethical and secure AI, (and) promoting a human-centric approach in the global context'[270]. The first 2 years of implementation have confirmed that joint actions and structured cooperation between Member States and the Commission are the key to the EU's global competitiveness and leadership in AI development and uptake.

The next steps should focus on the **implementation** of the joint actions and the **removal of fragmentation** between funding programmes, initiatives and actions taken at EU and Member State level. In order to facilitate this implementation, the Commission will assist with, and itself take the measures outlined in this review. It will provide practical and actionable guidance, ensure cooperation and provide frameworks and financial means through EU funding programmes, such as Horizon Europe and Digital Europe. Member States have also a unique opportunity through the RRF to make the most of AI in the digitalisation of their economy and their public administrations.

Specifically, the Commission will, in collaboration with the Member States, closely **monitor and follow up on the progress made in the implementation of the joint actions** agreed in the Coordinated Plan. This monitoring and follow-up work should be structured, well-designed and provide a dynamic mechanism for the collection and analysis of progress achieved. Member States are invited to support the Commission in this effort and closely collaborate by providing regular updates, analysis and reports on actions taken and progress achieved. They should share best practices and propose actions that could further enhance

269 See list of Candidates for European Partnerships in food, bioeconomy, natural resources, agriculture and environment proposed by the European Commission.

270 European Commission, Annex to the Coordinated Plan on Artificial Intelligence, (COM(2018) 795 final), p. 1.

synergies. Such structural and agile dialogue is necessary to ensure that the joint actions proposed in the Coordinated Plan deliver the intended synergies and added value.

The review of the Coordinated Plan and the feedback received from stakeholders suggest that there is **further potential for action to foster closer cooperation and coordinating common priorities and initiatives within AI.** Accordingly, the Coordinated Plan proposed actions **to reduce the fragmentation** between the different funding instruments, between actions taken on national and EU level, between research communities themselves and between research communities and industry. Among other things, such fragmentation results in unnecessary information and transaction costs, a lower return on investments, a waste of resources and finally in lost opportunities for EU businesses. In consultation with the general public, social partners, non-governmental organisations, industry, the academic community and national/regional authorities, the Commission will continuously assess how fragmentation may be further reduced.

In conclusion, this 2021 review builds on the strong collaboration between the EU and the Member States and the lessons learned from the first 2 years of implementation of the Coordinated Plan. It puts forward key actions whereby collaboration between the Member States and the EU can be reinforced further. The revised plan therefore provides a **valuable opportunity to strengthen competitiveness, the capacity for innovation and the responsible use of AI in the EU.** The fast development and uptake of innovative AI in the EU can contribute to solving key societal challenges and accelerate the digital and green transitions at a time when the global AI landscape is evolving fast.

Appendix 1 - **Timeline – key actions**

	2021 Review of the Coordinated Plan on AI Key Proposed Actions for European Commission and European Commission with Member States	Objectives: Mobilise resources	Create enabling conditions	Shape the development	Advance EU global position	2021	2022	2023	2024	2025+
I.	**SET ENABLING CONDITIONS FOR AI DEVELOPMENT AND UPTAKE IN THE EU**									
1	adopt a proposal for a Data Act and implementing act on public sector high-value data-sets reuse		x							
2	establish European Alliances for industrial data, edge and cloud, and for microelectronics and processors	x		x	x	Q2				
3	launch calls to build European data spaces and the European cloud federation under DEP, CEF2 and HE	x	x			x	x			
4	launch Industrial Alliance on Microelectronics	x			x					
5	launch calls through KDT JU and DEP to support the development of electronic components for AI	x		x	x	x				
6	continue to strengthen cooperation framework through AI Alliance, organization of annual AI Assemblies			x						
7	develop and enhance work of the Member States' Group on AI and DEI									
II.	**MAKE THE EU THE PLACE WHERE EXCELLENCE THRIVES FROM THE LAB TO THE MARKET**									
8	establish a co-programmed European partnership on AI, Data and Robotics	x	x	x	x	Q2				
9	set up AI Lighthouse for Europe		x	x	x			X		
10	launch AI related calls under HE					x				
11	launch calls for TEFs under DEP	x		x		x				
12	set up the network of EDIHs	x		x		x	x			
13	establish the AI-on-Demand platform as the central, European AI toolbox	x	x	x			x			
III.	**ENSURE THAT AI WORKS FOR PEOPLE AND IS A FORCE FOR GOOD IN SOCIETY**									
14	develop AI and Data usage ethical guidelines under the Digital Education Action Plan		x	x			x	X		
15	launch under the DEP calls for actions, programs and modules on skills for AI			x		x	x			
16	fund actions and projects on AI under the Marie Skłodowska-Curie programme		x	x		x				
17	propose a legislative action on horizontal framework on trustworthy AI		x	x	x	Q2				
18	propose adaptations to EU and national liability framework		x	x	x	x				
19	propose revisions of the existing safety legislation		x	x	x					
20	facilitate international dialogues on trustworthy and sustainable AI				x					
21	foster the setting of global AI standards, incl. development of AI requirements with the European Standard Setting Organizations		x		x					
IV.	**BUILD STRATEGIC LEADERSHIP IN HIGH-IMPACT SECTORS**									
	Bring AI into play for climate and environment									
22	launch calls under HE to develop sustainable AI solutions						x			
23	develop a roadmap for a common European Green Deal data space	x				Q2				
24	develop AI-supported digital simulation of the planet through the Destination Earth initiative	x			x	Q3				
25	explore KPI's to identify and measure negative environmental impact of AI			x						
	Use the next generation of AI to Improve Health									
26	set up infrastructure to interlink European databases of high-quality medical images	x					x			
27	set up a European Health Data Space									
28	launch calls under HE for the demand-driven AI-powered solutions for clinical needs			x		x				
	Maintain Europe's lead: Strategy for Robotics in the world of AI									
29	launch calls in robotics under DEP and HE towards the next generation of AI-powered robotics	x	x	x	x		x			
30	set up a robotics policy observatory in support of the robotics strategy			x			x			
31	conduct a review of regulatory obstacles		x			x	x			
	Make the public sector a trailblazer for using AI									
32	design a Public Procurement Data Space	x	x	x		x				
33	launch the Adopt AI programme for the public sector			x		x				
34	launch deployment and scale-up of AI-powered Urban Digital Twins			x		Q4				
	Apply AI to law enforcement, migration and asylum									
35	set up a common European Security Data Space for law enforcement	x	x	x	x		Q1			
36	fund UN ICJRI project to develop a global toolkit for law enforcement agencies			x	x	Q1				
	Make mobility safer and less polluting through AI									
37	propose an AI roadmap on mobility		x			x				
38	establish a co-programmed European Partnership CCAM	x	x	x						
	Support AI for sustainable Agriculture									
39	establish a European Public Private Partnership on 'Agriculture of Data'	x	x					x	x	
40	set up an agriculture data space	x	x					x	x	

x	a starting date, first call or launch of a program takes place during the marked year
Q2	a starting date, first call or launch of a program takes place during the marked quarter
	Continuing action
	No foreseen action

Please refer to the Coordinated Plan chapters for full details on the planned actions

HE = Horizon Europe research and innovation framework programme

DEP = Digital Europe funding programme for digital technologies

Appendix 2

Analysis of national strategies and investments in AI[271]

1. Overview of the national strategies

Table 1

National AI strategies, EU Member States and Norway (by date of initial adoption)

COUNTRY	STATUS	DATE
Austria	In progress	
Belgium	In progress	
Bulgaria	Published	Dec 2020
Croatia	In progress	
Cyprus	Published	Jan 2020
Czechia	Published	May 2019
Denmark	Published	Mar 2019
Estonia	Published	Jul 2019
Finland	Published	Oct 2017
France	Published	Mar 2018
Germany	Published	Nov 2018
Greece	In progress	
Hungary	Published	Sep 2020
Ireland	In progress	
Italy	In progress	
Latvia	Published	Feb 2020
Lithuania	Published	Mar 2019
Luxembourg	Published	May 2019
Malta	Published	Oct 2019
Netherlands	Published	Oct 2019
Norway	Published	Jan 2020
Poland	Published	Dec 2020
Portugal	Published	Jun 2019
Romania	In progress	
Slovakia	Published	Jul 2019
Slovenia	In progress	
Spain	Published	Dec. 2020
Sweden	Published	May 2018

Source: AI Watch – European Commission[272].

A total of 19 Member States (most recently Spain and Poland, in December 2020), plus Norway have adopted strategies. Some Member States (e.g. Finland, Cyprus and Germany), have already updated and reviewed their initial strategies[273].

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271 The information in this Appendix sections 2 and 3 is based on the input received from Member States. Sections 2 and 3 cover all Member States that have provided information on the request of the Commission services.

272 The information in the table is based on input from national contact points or public sources gathered in the context of AI Watch. In addition to EU Member States, this table also covers Norway as an associated country. The table was last updated on 14 April 2021.

273 Implementing its AI strategy, Finland updated its strategy in 2020 launching a national AI programme ('AI 4.0') in November 2020. The programme promotes the development and introduction of AI and other digital technologies in companies, especially SMEs with a special focus on industry. The update provided a list of concrete policy actions and an implementation plan for the coming years and presented a vision for AI until

The national AI strategies and supporting policies differ in terms of strategic approach, level of detail of proposed actions, and sectoral focus.

Member States have employed different approaches in developing their national AI strategies, ranging from a high-political-level umbrella strategy, covering many different policy initiatives, to operational strategies with concrete actions and an allocated budget envelope.

For example, the 2020 update of the German AI strategy reacts to new developments in the field of AI, focuses its initiatives on five fields of action and adds 87 measures that the federal government intends to implement by 2022. As part of the German COVID-19 recovery package, the German federal government has increased its financial commitment to AI by EUR 2 billion to EUR 5 billion by 2025[274]. Estonia's strategy provides a comprehensive overview of existing and proposed policy measures, along with their objectives, deadlines and budget estimations. Spain's strategy proposes 30 measures over six fields of action, including substantial funding for companies in the form of aid and public-private venture capital. The strategy also foresees a Green AI programme, aiming at fostering the development of efficient algorithms and their use for environmental problems.

Some Member States have included measures to support the development and deployment of AI as part of other digitalisation strategies. For example, the Bulgarian Concept for the Development of Artificial Intelligence is based on the national strategic document 'Digital Transformation of Bulgaria (2020-2030)' approved in July 2020 and takes into account measures on AI development and deployment envisaged in some sectoral strategies. The forthcoming Belgian national strategy is a combination of the three regional strategies (in accordance with the intra-Belgian distribution of competencies) with their own focus and priorities and the federal focus and priorities.

National policies also differ in terms of priority sectors for action. Some Member States (e.g. Malta and Slovakia) took a horizontal approach and did not identify specific priority sectors. Others focused on the economic sectors that have a high growth potential or provide a competitive advantage, e.g. France and Italy list measures across a wide range of well-elaborated sectors of importance for their economies. The most commonly covered in the national AI strategies sectors are manufacturing, healthcare, agriculture, public administration, transportation, logistics, education and energy. In addition to the mainstream sectors of application of AI, a number of Member States have planned actions, for example, in the maritime sector (Cyprus), weather forecasting (Germany), art and culture (Italy), biodiversity (Portugal), justice (Latvia), and fashion (Spain). Some have a very specific focus for implementation of AI by prioritising a particular sector, e.g. energy (Lithuania) or water (Netherlands).

2. Outlook – forthcoming national actions

Austria expects to publish its strategy by the end of Q2 2021, subject to the final political coordination. The strategy defines the framework conditions for a prosperous, responsible and safe use of AI in all areas of life in accordance with European requirements for trustworthy AI. The objectives of the Austrian strategy are formulated in close coordination and comprehensive agreement with the AI foundations, objectives and joint action of the European Union. Key focus areas will include regulatory framework (ethics, legal), safety and

2025. After a regular review of its national AI strategy, in June 2020 Cyprus has launched a procurement for tender to develop an Action Plan that will detail the progress and implementation of the national AI strategy. Germany, adopted the update of the AI strategy in December 2020.

274 The initial 2018 AI strategy committed EUR 3 billion in AI investments; the updated version pledged an increase to EUR 5 billion by 2025.

security of AI, defining standards, AI infrastructure, data use and sharing, conditions for R&D&I, transfer and uptake of AI, cooperation between education, research and business societal dialogue and creating awareness, and AI in the public sector.

Belgium: three regional strategies and AI programmes have been adopted and rolled out in the period 2017 till 2019. In June, 2020 a report to define a common, national AI action plan has been approved by all Belgian entities. Given that the adoption of this plan is a priority for the federal government, discussions in this direction between all the competent authorities are forthcoming. The aim is to create a coherent political framework that can promote synergies between the different policy areas and the different competent entities.

Bulgaria: the Council of Ministers adopted the national strategic document (*Concept for the development of AI in Bulgaria until 2030*) in December 2020.

Croatia has prepared a draft National Plan for the Development of Artificial Intelligence for the period from 2021 to 2025. The working group drafted the National Plan and will finalise the document by elaborating concrete measures, which are expected to be completed by the end of 2021. In drafting the National Plan, the guidelines of key strategic documents at EU level were taken into account: Coordinated Plan on Artificial Intelligence and the White Paper on Artificial Intelligence.

Czechia will be updating the National AI strategy in accordance with the new Coordinated Plan.

Denmark is currently considering the best way to address and if needed revise the existing national AI strategy from 2019.

Estonia's strategy is coming to an end in July 2021. Estonia will review and update it in 2021. It has exceeded expectations and Estonia sees wide adoption and use of AI – with over 50 AI use-cases deployed by the public sector. With the increased number of AI use-cases, the competence/skills related to AI have significantly improved. However, there are still legislative issues that need to be tackled and worked on, for instance, removing outdated norms to enable automating administrative proceedings.

Finland launched an updated national AI programme in November 2020. The AI 4.0 programme promotes the development and introduction of AI and other digital technologies in companies, especially SMEs with a special focus on industry.

France launched in 2018 the first phase of the French national strategy in AI, with a budget of EUR 800 million for 3 years, put a strong emphasis (1/3 of spending) on boosting research, with the creation of interdisciplinary institutes 3IA, the extra financing of 180 PhDs and the opening of a petascale supercomputing facility. The second phase of this strategy (2021-2022) sets main priorities on the development of embedded AI and trustworthy AI in critical systems in order to strengthen the national industrial base while accelerating the digital and ecological transition of companies thanks to AI. AI education and retraining will also be a major direction.

Germany updated its strategy in December 2020. The review draws up an interim balance, shows relevant developments at national, European and international level, and sets out concrete measures to be implemented by 2022. The update report focuses on the following fields of action: research, knowledge and expertise, transfer and application, regulatory framework and society. In addition, new initiatives will focus on sustainability, environment/climate protection, pandemic control and international/European cooperation.

Greece has progressed towards the finalisation of the National Strategy on AI and estimates to have it ready by the end of April 2021. The Hellenic Ministry of Digital Governance (MDG) is the owner and coordinator of the strategy. The timing has been adapted in order to accommodate the COVID-19 lockdown situation and the reform of the Greek government as of January 2021.

Hungary's AI strategy was published in September 2020 and is based on input from the member organisations of the Hungarian AI Coalition. The strategy aims for a comprehensive approach across the AI value chain, such as the development of the Hungarian data economy, development of the necessary infrastructure, widespread education and training activities, incentivising the uptake of AI solutions (both in the private and public domain), as well as a regulatory environment that strikes a balance between safety and innovation. The execution of sectoral goals is based on multilateral cooperation between the relevant actors, i.e. in agriculture, transportation, health and public administration.

Ireland expects to publish its strategy in Q2 2021, subject to the necessary conditions being met. Key focus areas will include: societal opportunities and challenges of AI; driving adoption of AI by Irish enterprise; public-sector use of AI; a strong AI innovation ecosystem; AI education, skills and talent; a supportive data, digital and telecommunications infrastructure, and the governance and regulatory framework (including human rights, ethics and standards).

Latvia is implementing its strategy which was released in February 2020. Currently planned key initiatives are digitalisation with a focus on AI, supplementation of new language pairs for machine translation systems, skill improvement in the field of natural language processing, analytical machine learning tools for crime investigation and development of an AI-based proactive services model for citizens.

Lithuania is currently considering a review and, if necessary, an update of the existing national AI strategy from 2019. Investment measures are being planned to support the development of language resources for use in AI, as well as support schemes for AI start-ups, and for businesses performing AI transformations.

Luxembourg launched a call for projects for ministries to submit ideas for AI-based initiatives that would help them optimise or expand their services in November 2019. The call drew a total of 14 projects from seven different administrations: six winning teams received funds to kickstart its project along with guidance on procurement, design and service provider selection. After 6 to 9 months of development, a completed proof of concept and mock-up will help determine if the project should move forward. Also, a team of legal experts on data and technology evaluated and assisted the finalists. This learning experience brings lasting value to Luxembourg's public administration. A second call was launched in the beginning of 2021. In addition, the free Elements of AI course has officially arrived in Luxembourg. Another important element of the strategy was the launch of a public consultation on AI at the end of 2020, the results will be presented at the end of April 2021.

Netherlands is implementing the actions from the national strategic action plan on AI. An overall update of the national strategy for digitalisation (and AI) will follow in Q2 2021. Focus will be on requirements for human-centric AI, a vivid research and innovation ecosystem (public private partnership), human capital, international cooperation, deployment (SMEs) and applications: public sector use, smart industry and AI for societal challenges: health, energy transition, agriculture, mobility.

Poland adopted 'Policy for the Development of Artificial Intelligence in Poland from 2020' in December 2020. It is focused on actions on society, education, science, business, public affairs and international relations under the strategic mission of protecting human dignity of people and supporting condition of fair competition in global rivalry. Poland implements the Trustworthy AI ethical framework and launches mechanism of flourishing polish ecosystem of AI in ethical, legal, technical-operational and international dimensions. Poland established the centre of coordinated governance hosted by the Prime Minister acting as the Minister of Digital Affairs. It consists of AI Policy Enforcement Task Force, Ad hoc AI Science Committee, AI Labour Market Observatory, AI International Policy Observatory, Legal Task Force and Ministries Committee of Digitization.

Romania has initiated multiple efforts towards drafting and implementing the AI national policy framework. In 2020, Romania launched an EU-funded project on creating a national framework in the AI field for the 2021-2027 period. The AI framework will include aspects such as the development of education and skills in AI, increase the R&D and innovation in AI both in the academic and industrial areas, strengthen cooperation in developing AI infrastructures, adopt ethical AI and data protection parameters at best practice level and overlap the cybersecurity priorities of these pillars. This effort will involve expertise from the government, academic and private sector, be supported by technological and legal consultancy services, and will result in the national strategic framework for AI. The objective will be implemented throughout 2021 and 2022.

Slovakia will be updating its AI measures published in the action plan in accordance with the revised Coordinated Plan.

Slovenia is in the final stage of adoption of the National programme for AI 2020-2025 that aims at diffusing AI research knowledge gathered in more than 40 years of national AI research activities, into new innovative products and services in six priority areas, targeting the whole innovation lifecycle and building a vibrant national ecosystem that will assure appropriate public awareness, skill set and trust in AI. The National programme for AI has ten strategic goals including concrete actions to achieve them. These include direct support for research, innovation and implementation; support for development of a vibrant ecosystem for innovation and uptake of AI; assuring proper digital skills; effective regulation; public trust; and proper international cooperation.

Spain's 2021-2023 Spanish National Strategy on Artificial Intelligence, of December 2020, aspires to make AI contribute to consolidating its welfare state, also providing the necessary data and assets to boost innovation and technological development. The Strategy foresees a comprehensive approach, which will prepare society for AI disruption with adequate skills and a trustworthy framework, while the research community is empowered to provide innovative solutions that will ultimately be adopted by the value chains, including SMEs. As a key element of the Strategy, sustainability is supported by a Green AI programme, aiming at the efficiency of the algorithms and their use for environmental problems.

Sweden is working on a strategy for secure access to open data and the use of data as a strategic resource, with respect for rules on data protection and privacy and based on the premise that data is a basic prerequisite for being able to use the potential in AI and other digital innovation. The strategy will be published in 2021 and is an important complement to the previously published national AI strategy.

Norway published its strategy in January 2020. The strategy addresses important topics for AI such as data and data management, language resources, infrastructure for communications and computing, research and higher education, skills, and AI-driven innovation in both the

public and private sector. The strategy establishes ethics principles for development and use of trustworthy AI in Norway. The strategy has been well received, and the government is working to follow up on the many policy initiatives of the strategy. One important milestone was the launch of a regulatory sandbox for AI with the Data Protection Authority in December 2020. Data and access to data has also been a priority, and a government white paper on the data-driven economy was presented to the parliament in March 2021.

Switzerland does not have a dedicated strategy on AI. However, some aspects in the application of AI are addressed in the new strategy 'Digital Switzerland' of September 2020. In addition, the Swiss government adopted specific guidelines for AI in November 2020, which are intended to provide the federal administration and the agencies entrusted with administrative tasks with a general orientation framework and ensure a coherent AI policy. Regular evaluation of the application and further development of these guidelines is planned.

3. Member States' investments in AI

Many national AI strategies provide estimates of necessary investments or allocate an itemised budget for concrete actions. Numbers vary greatly and are difficult to compare, as they are presented according to different timeframes and coverage. The following gives some indications of the order of magnitude of allocated funding:

- The German government initially earmarked EUR 3 billion for the implementation of the German strategy in 2019-2025; it has now increased this to EUR 5 billion.
- The French government will dedicate EUR 1,5 billion to AI development by the end of 2022.
- Denmark has allocated DKK 200 million (c. EUR 27 million) to an investment fund for testing, scaling and encouraging the uptake of AI in the public sector, with a particular focus on healthcare, public administration and the green transition.
- Spain has set aside EUR 600 million for the period 2021-2023 and expects to mobilise EUR 3,3 billion in private investment. For the year 2021, EUR 330 million have been budgeted.
- Sweden's innovation agency Vinnova funded AI projects for SEK 675 million (c. EUR 67,5 million) in 2020. The total sum for AI projects that Vinnova helped fund was SEK 1,350 billion (c. EUR 135 million), 50% of this could be private founding or funding from other national programs. In the national budget for innovation and research until 2024 at least SEK 550 million (c. EUR 55 million) has been assigned to research and innovation in digital technologies and AI and its use and impact on society.
- The Dutch strategy mentions in an annex that the yearly governmental budget for AI innovation and research is estimated at EUR 45 million per year. In 2019 this budget was EUR 64 million. In 2020 the Netherlands funded an additional EUR 23,5 million for the Public Private Partnership the Dutch AI Coalition. In April 2021 an investment programme was granted to maximise the possibilities of AI for the Dutch economy and society by investing an additional amount of maximum EUR 276 million in the upcoming years.
- The Finnish government provides investment figures for various flagship policies, e.g. it allocated EUR 100 million over a 4-year period for the 'AI business' programme. The Finnish Centre for Artificial Intelligence (FCAI) has been granted EUR 8,3 million in flagship funding for 2019-2022.
- To implement the AI strategic objectives, Slovenia earmarks an investment of EUR 110 million of public funding in its draft National programme for AI until 2025.

- Since the adoption of the National AI strategy in 2019, there have been several projects supported by the Technological Agency of the Czech Republic, Czech Science Foundation (national budget resources), etc. for EUR 120 million in total.