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POLICY AND INVESTMENT RECOMMENDATIONS FOR TRUSTWORTHY AI

POLICY AND INVESTMENT RECOMMENDATIONS

FOR

TRUSTWORTHY AI

High-Level Expert Group on Artificial Intelligence

This document was written by the High-Level Expert Group on AI (AI HLEG). It is the second deliverable of the AI HLEG and follows the publication of the group's first deliverable, Ethics Guidelines for Trustworthy AI, published on 8 April 2019.

The members of the AI HLEG named in this document support the overall framework of recommendations put forward in this document, although they do not necessarily agree with every single statement therein.

The AI HLEG is an independent expert group that was set up by the European Commission in June 2018.

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INTRODUCTION

In its various communications on artificial intelligence (AI)[1] the European Commission has set out its vision for AI, which is to be trustworthy and human-centric. Three pillars underpin the Commission's vision: (i) increasing public and private investments in AI to boost its uptake, (ii) preparing for socio-economic changes, and (iii) ensuring an appropriate ethical and legal framework to protect and strengthen European values. To support the implementation of this vision, the Commission established the High-Level Expert Group on Artificial Intelligence (AI HLEG), an independent group mandated with the drafting of two deliverables: a set of AI Ethics Guidelines and a set of Policy and Investment Recommendations.[2]

In our first deliverable, the *Ethics Guidelines for Trustworthy AI*[3] published on 8 April 2019 (Ethics Guidelines), we stated that AI systems need to be human-centric, with the goal of improving individual and societal well-being, and worthy of our trust. In order to be deemed trustworthy, we put forward that AI systems – including all actors and processes involved therein – should be lawful, ethical and robust. Those Guidelines therefore constituted a first important step in identifying the type of AI that we want and do not want for Europe, but that is not enough to ensure that Europe can also materialise the beneficial impact that Trustworthy AI can bring.

Taking the next step, this document contains our proposed Policy and Investment Recommendations for Trustworthy AI, addressed to EU institutions and Member States. Building on our first deliverable, we put forward 33 recommendations that can guide Trustworthy AI towards sustainability, growth and competitiveness, as well as inclusion – while empowering, benefiting and protecting human beings. We believe that EU Institutions and Member States will play a key role in the achievement of these goals, as a pivotal player in the data economy, a procurer of Trustworthy AI systems and as a standard-setter of sound governance.

Our recommendations focus on four main areas where we believe Trustworthy AI can help achieving a beneficial impact, starting with humans and society at large (A), and continuing then to focus on the private sector (B), the public sector (C) and Europe's research and academia (D). In addition, we also address the main enablers needed to facilitate those impacts, focusing on availability of data and infrastructure (E), skills and education (F), appropriate governance and regulation (G), as well as funding and investment (H).

These recommendations should not be regarded as exhaustive, but attempt to tackle the most pressing areas for action with the greatest potential. Europe can distinguish itself from others by developing, deploying, using and scaling Trustworthy AI, which we believe should become the only kind of AI in Europe, in a manner that can enhance both individual and societal well-being.

Europe is well placed to seize AI's opportunities

Europe is entering the third wave of digitalisation, but the adoption of AI technologies is still in its infancy. The first wave involved primarily connection and networking technology adoption, while the second wave

[1] European Commission communications published on 25 April 2018 (COM(2018) 237 final), 7 December 2018 (COM(2018) 795 final) and 8 April 2019 (COM(2019) 168 final). For our definition of Artificial Intelligence (AI), please refer to our document published on 8 April 2019: "A Definition of AI: Main Capabilities and Disciplines" which was prepared for the purpose of our deliverables and can be found here: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=56341.

[2] For more information on the AI HLEG, see https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence.

[3] These are available at: https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai.

was driven by the age of big data. The third wave is characterised by the adoption of AI which, on average, could boost growth in European economic activity by close to 20% by 2030.[4] In turn, this will create a foundation for a higher quality of life, new employment opportunities, better services, as well as new and more sustainable business models and opportunities.

However, as is the case with any technology, AI can be deployed both in a manner that increases human well-being and that may lead to potential harm. Therefore, while it creates a great opportunity for Europe, it also implies certain risks of which policy-makers are increasingly aware. This may necessitate specific and targeted governance measures that provide appropriate safeguards to protect individuals and society. In this report, we make recommendations to position Europe so that it can maximise the extent to which it can benefit from the opportunities presented by AI, while simultaneously ensuring that these benefits are felt throughout the entire European society, and that any risks are prevented or minimised.

When analysing the international landscape regarding key markets and investments for AI, there are significant differences in focus across the largest economies in the world, including the U.S., China and Europe. The market for AI is much broader than business-to-consumer (B2C). More specifically, it also includes business-to-business (B2B) platforms and markets, in which substantial industrial value is created. In fact, studies indicate that one third of the value created by AI is contributable to the B2C segment, and two-thirds to the B2B, where Europe has a traditionally strong footprint.[5]

In addition, a third segment can be identified when considering public-to-citizens (P2C) services that are increasingly procuring and deploying digital and AI-enabled solutions and where the trust of individuals is an even more crucial prerequisite. The P2C context or Digital Government is emerging very rapidly, leading to a potential revolution in the role and structure of government and its relationship with individuals and businesses.[6]

Within each of these three segments, an additional level of granularity is needed to understand their underlying logic. Therefore, we should disentangle AI systems that consist of a digital element only, from AI systems that combine both digital and physical components. This leads to a more comprehensive picture, comprised of six different yet connected segments with their own specific logic for growth, competitiveness and governance.

This more holistic vision lends itself to the creation of a European Single Market for Trustworthy AI, where Europe is in an exceptional position to put tailored policy and investment measures in place that can enable it to seize the benefits and capture the value of AI, while minimising and preventing its risks.

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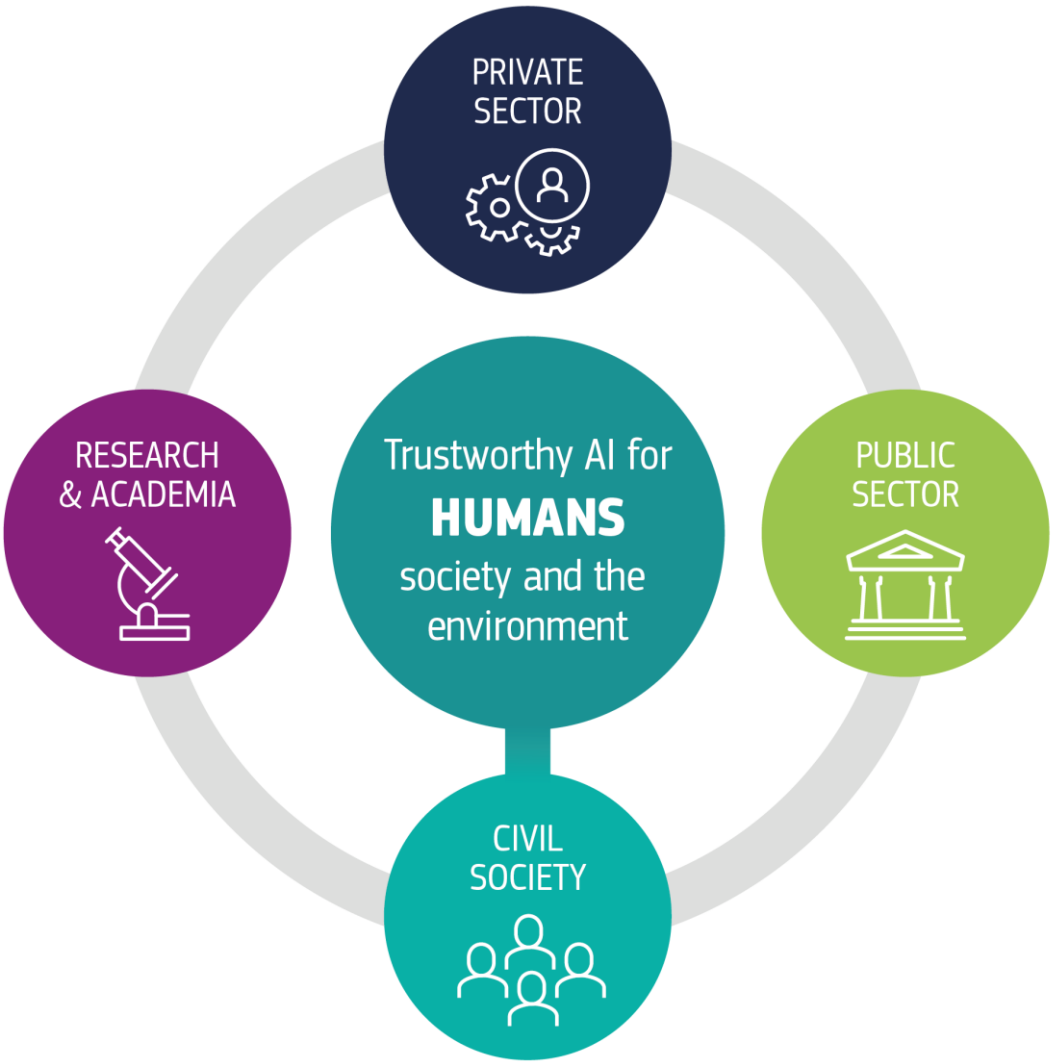
4 See Notes from the AI Frontier: Tackling Europe's Gap in Digital and AI, McKinsey Global Institute, 2019.

5 See Notes from the AI Frontier: Modelling the Impact of AI on the World Economy, McKinsey Global Institute, 2018.

6 See Deloitte Insights, How artificial intelligence could transform government (2017), available at: https://www2.deloitte.com/insights/us/en/focus/artificial-intelligence-in-government.html.

CHAPTER I

USING TRUSTWORTHY AI TO BUILD A POSITIVE IMPACT IN EUROPE



CHAPTER I: USING TRUSTWORTHY AI TO BUILD A POSITIVE IMPACT IN EUROPE

In this chapter, we focus on four major areas of impact that merit a specific focus: (A) Humans and Society, (B) the Private Sector, (C) the Public Sector and (D) Research and Academia.

(A) As already stated in our Ethics Guidelines, in building a future with AI, our point of departure is **human-centricity**. By placing the human at the centre of our thinking, we underscore the fact that AI is not an end in itself, but a means to enhance human well-being and freedom. All policy recommendations that we put forward in this document have this as their direct or indirect goal. Human-centricity, however, not only implies attention to individuals, but also to the well-being of society at large and the environment that humans live in. Europe should champion the use of AI towards sustainable development in line with the Agenda 2030.

(B) For Europe to tackle the opportunities and challenges created by AI, it needs a thriving and vibrant **private sector**. The private sector is a key player in generating economic growth and creating relevant and growing employment opportunities through its success. The uptake and scaling of AI solutions as well as the stimulation of innovation and technology transfer can help achieving this. At the same time, a key success factor for the private sector is the ability to understand the specific needs in different businesses and sectors. Collaboration with the public sector and civil society, research and academia as well as with policy-makers is essential for gaining such understanding and generating AI-enabled solutions to the benefit of all.

(C) Equally, the **public sector** has a crucial role to play at both individual and societal level in the adoption of Trustworthy AI. The current transformation of governments towards more efficient and digitised public services might represent a fundamental shift in the way in which the economy and, in particular, the Single Market, is structured and organised. Harnessing the public sector "as a platform" could lead to new opportunities for researchers and entrepreneurs to gain access to data and infrastructure for developing welfare-enhancing AI solutions through privacy-preserving means. The public sector can make strategic use of public procurement to foster responsible innovation, as well as steering it towards tackling societal challenges and the development of trustworthy AI solutions. Moreover, by delivering higher quality, more targeted and thus more effective services to individuals and groups where appropriate, it can also act as a catalyst for innovation and growth.

(D) The bedrock of any successful transition is the ability to understand the changes we are facing. The role of **research and academia** is therefore essential in creating the foundational layer for all actors and activities needed for Europe to master these changes. Research, both academic and industry-based, enables us to understand and address emerging challenges and can help turn the development of AI towards the common good. It can also provide the interdisciplinary and multidisciplinary mix that is needed to ensure AI's trustworthiness, and foster our understanding on the impact of new and existing policies. Research is also an engine of creativity, beneficial innovation and new ventures through technology transfer, offering solutions that can be embedded into useful products. Finally, research and academia are key providers of education and skills, which are essential in a world where "intelligent" systems perform an increasing number and variety of tasks.

In what follows, we elaborate on each of those areas, indicating which impact we wish to achieve with AI and providing a number of recommendations on how this can be accomplished.

A. Empowering and Protecting Humans and Society

AI presents a promising means to enhance individual and societal well-being and the common good, as well as driving progress and responsible innovation. Yet it also carries risks for humans and societies, which need to be identified and addressed. Hence, we need to foster AI solutions that can empower human beings, and monitor the impacts they create, ensuring that this happens in a way that protects our rights and values. It is therefore essential that individuals gain awareness, knowledge and understanding of the capabilities, challenges and limitations of AI systems, and of their rights related thereto.

The impact of AI systems on individuals and society at large needs to be better understood, so as to enable actions to guide the technology's development and use towards the vision we set out in our Ethics Guidelines. This requires research, new monitoring and measuring mechanisms, as well as measures that can protect individuals and society from potential adverse impact generated by the technology. Below, we reflect on the policies that should be put in place to achieve this goal.

1. EMPOWER HUMANS BY INCREASING KNOWLEDGE AND AWARENESS OF AI

In order to build a society supported by AI that we would like to live in, it is imperative that not only AI experts, but also society at large is aware of the possibilities and limitations of the application of AI systems. The following actions are recommended in this respect:

1.1 Encourage Member States to increase digital literacy through courses (e.g. MOOCs) across Europe providing elementary AI training. This includes fostering the understanding of AI systems more generally (including a basic understanding of machine learning and reasoning), but also raising awareness of data protection rights, an understanding of how (personal) data can be used, the implications of digital tracking, and the importance of issues such as fairness, explainability, transparency, robustness of AI systems, and knowledge of these topics. Efforts need to be made to ensure that such courses are accessible to all, taking due account of the digital divide and paying particular attention to the lower skilled and disadvantaged. A universal design approach should be inherent in all of these programs. The outreach and popularity of national public broadcasters can also be leveraged to develop educational programmes on AI, outlining its main opportunities, possible risks and ways to mitigate them.

1.2 Encourage Member States to support and further develop basic education on AI and digital literacy, particularly in primary, secondary and tertiary education systems, as well as beyond. This includes supporting young people through EU youth policies and funds who are leading projects aiming at educating and informing individuals on opportunities and challenges of new technologies. However, it also includes fostering AI knowledge amidst the less young, encompassing employees, executives, civil servants, policy-makers and all other individuals. The education and nurturing of STEM and more specifically AI experts not only as technology drivers, but also as enablers for society on all levels, needs to be emphasised, supported and extended. Further recommendations on the fostering of skills and education can be found under Section F.

1.3 Create an AI competence framework for individuals, including a focus on the core skills required. This includes directing the Digital Competence Framework for Citizens[7] – as a tool to improve digital

[7] For more information, see https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-21-digital-competence-framework-citizens-eight-proficiency-levels-and-examples-use.

competences. All individuals should be empowered with the necessary skills to use AI technology, beyond being recipients of information on the technology. In addition, they should be able to make use of tools to challenge public governance through AI systems, as addressed under Recommendation 12.3 below.

1.4 ***Institutionalise a dialogue between policy-makers, developers and users of AI technology, for instance through the European AI Alliance***, on the ethical and legal limits of AI and examine how the policy and regulatory framework needs to be further developed in order to guarantee legal certainty and foster beneficial innovation while ensuring due respect for human rights, democracy and the rule of law. A widespread mechanism of public consultation should be ensured on the most ethically sensitive issues revolving around AI systems with a significant impact on society or individuals. Besides enabling a dialogue through the European AI Alliance, such mechanisms are also needed at Member State level to respect linguistic and cultural diversity.

1.5 ***Inform the public at large about free available resources on AI that they can use to learn and experiment (e.g. algorithms and data), to discuss (e.g. via blogs) and to share best practices***. This could be done by creating a repository on the European AI Alliance platform. Moreover, publicly financed and subsidised programmes in the media and social networks as well as non-formal education organisations that provide training and awareness-raising on data protection, coding, robotics and data (including data protection), should be supported.

1.6 ***Establish a yearly European AI Awareness Day*** (for instance, on the birthday of Alan Turing) with awareness material to be used for the event.[8] This should be accompanied by a European AI Awareness website, which could also provide answers to common questions related to AI (in the form of a "FAQ").

2. PROTECT THE INTEGRITY OF HUMANS, SOCIETY AND THE ENVIRONMENT

AI can provide tools to help safeguarding the integrity of our public institutions and the private sector (e.g. by detecting and proving discrimination), the privacy of individuals (e.g. by detecting and rooting out privacy infringing content) as well as the environment (e.g. by improving the detection of pollutants and their sources). However, if not applied in a trustworthy manner, AI systems could cause adverse impacts to individuals, society and the environment, such as unjust discrimination or bias, privacy infringement, social or economic exclusion or environmental decline. Adequate protection should be put in place to counter such impacts.

2.1 ***Refrain from disproportionate and mass surveillance of individuals.*** While there may be a strong temptation for governments to "secure society" by building a pervasive surveillance system based on AI systems, this would be extremely dangerous if pushed to extreme levels. Governments should commit not to engage in mass surveillance of individuals and to deploy and procure only Trustworthy AI systems, designed to be respectful of the law and fundamental rights, aligned with ethical principles and socio-technically robust.

2.2 ***Commercial surveillance of individuals (particularly consumers) and society should be countered***, ensuring that it is strictly in line with fundamental rights such as privacy – also when it concerns "free" services – taking into consideration the effects of alternative business models.

2.3 ***Consideration should be given to power asymmetries between institutions, businesses and individuals arising from the growth of digital devices and systems and the rapid expansion of***

[8] This could for instance include a "1 hour AI" initiative, similar to 1-hour code initiatives (see e.g. https://hourofcode.com).

digital data that they generate. Where appropriate, for instance in situations of individual or collective harm, consideration should be given to whether potential measures may be needed to address this.

2.4 ***Introduce a mandatory self-identification of AI systems.*** In situations where an interaction takes place between a human and an AI system, and whenever there is a reasonable likelihood that end users could be led to believe that they are interacting with a human, deployers of AI systems should be attributed a general responsibility to disclose that in reality the system is non-human. This goes hand-in-hand with ensuring the transparency of AI systems.

2.5 ***Foster the development of AI solutions that address sustainability challenges***, by launching competitions and missions for AI solutions tackling specific environmental problems, strengthening this component in the Horizon Europe missions, and enact a circular economy plan for digital technologies and AI in particular to incentivise companies to reduce the carbon footprint of data centres and devices (including smartphones). Consideration must be also given to the sustainability of big data-driven AI and modern computing and AI architectures to ensure that the process of developing AI products and services also does not have an undue sustainability impact.

3. PROMOTE A HUMAN-CENTRIC APPROACH TO AI AT WORK

Over the past years, an important debate has taken place on the impacts that the increased diffusion of AI systems and, more generally, the digital transformation of the economy will have on the labour market. The European Commission appointed a dedicated High Level Expert Group[9] on this issue, which released a report[10] in April 2019. A few months earlier, the EGE[11] likewise dedicated a report[12] on this topic. We refer to that report for a more detailed analysis of existing trends and possible measures to ensure that digital technologies do not negatively disrupt the workplace, and that adequate social protection, collective representation and training are offered to European workers. Here below, we will limit ourselves to those recommendations which we believe are crucial to also take up in this document, against the broader context of the goals we set out to achieve, particularly focusing on the impact of the use of AI in the workplace. We note that this section also covers the domestic working environment, covering those who engage in domestic work, as well as situations where work is carried out on an unpaid basis.

3.1 ***Promote the research, development and deployment of human-centric AI systems in work contexts without stifling socially beneficial innovation.*** A careful consideration of challenges associated with socio-technical work systems integration, be it issues of safety and security, human oversight or deskilling, will allow the full exploitation of AI-driven automation. Research funding, technology transfer and deployment, tax policy and government demand-side policies should be aimed at creating collaborative AI-human work systems without preventing innovation and aiming to avoid menial jobs, especially in situations where automation is a cost-efficient alternative, enabling governments to allocate funds for the creation of more productive jobs and improving the social well-being of individuals. This could also drive the reshoring of jobs to Europe. Moreover, human-empowering AI applications could also create new job opportunities in particular for those who – because of natural restrictions such as disabilities or living circumstances

[9] For more information on this expert group, see: https://ec.europa.eu/digital-single-market/en/high-level-expert-group-impact-digital-transformation-eu-labour-markets.

[10] Available at: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=58412.

[11] The European Group on Ethics in Science and New Technologies (EGE) is an independent expert group established by the European Commission and focusing on ethical aspects of science and technology relating to EU legislation and policies.

[12] Available at: https://ec.europa.eu/info/sites/info/files/research_and_innovation/ege/ege_future-of-work_opinion_122018.pdf.

– were initially bound to less qualified jobs. Automation can also serve humans with natural restrictions in making their lives more convenient and meaningful.

3.2 ***Encourage automation of dangerous tasks and when humans are put at risk***, to ensure safe working conditions at work. Special efforts should be made to find ways of automating tasks in which workers are put in danger (e.g. facing accidents, harsh environmental conditions, or long-term ailments of exposure to harmful substances) even if these are less cost-efficient than using a human workforce. European institutions should put efforts to increase awareness of the value of automation in such situations and support organisations through funding of special projects, aiming to avoid menial jobs and dangerous working conditions.

3.3 ***Apply a process of representation, consultation and, where possible, co-creation***, where workers are involved in the discussion around AI production, deployment or procurement process in order to ensure that the systems are useable and that the worker still has sufficient autonomy and control, fulfilment and job satisfaction. This implies informing and consulting workers when developing or deploying AI, as set out in the existing texts adopted by the European institutions and the social partners.[13] Workers (not only employees but also independent contractors) should be involved in discussions around the development, deployment or procurement of algorithmic scheduling and work distribution systems, to ensure compliance with health and safety legislation, data policy, working time legislation and work-life balance legislation. Social dialogue plays a key role to enable this.

3.4 ***Map value chains in Europe and engage in horizon scanning to gain an understanding of which skills will become less relevant, and which ones will be more in demand or at risk of shortage.*** This can enable a more targeted policy to help workers transition between jobs or acquire necessary new skills, to incentivize organisations to conduct such mapping at organisational level, to anticipate the new skills that their workers may need, and to foster the development of those skills in a timely manner.

3.5 ***Establish a full-fledged European transition fund to help managing the AI transformation in a socially responsible way.*** This can be aligned with the process of reinforcing the European Globalisation Adjustment Fund.

4. LEAVE NO ONE BEHIND

The benefits of AI should be shared with all parts of society, leaving no one behind. This is also in line with the Agenda 2030, and should be actively pursued by the EU and Member States.

4.1 ***Introduce a duty of care for developers of consumer-oriented AI systems to ensure that these can be used by all intended users, fostering a universal design approach***, and do not lead to the exclusion of users with disabilities, particularly when used in public services. More generally, AI developers should be incentivised to adopt a universal design approach to AI, which entails considering the benefits and concerns relating to all societal groups, such as the elderly, children,

[13] See for instance Articles 151 and following of the Treaty on the Functioning of the EU, dealing with social policy. For more information on European social dialogue, see https://ec.europa.eu/social/main.jsp?langId=en&catId=329. For more information about EU Directives and action concerning employee involvement, see https://ec.europa.eu/social/main.jsp?catId=707&langId=en. In this regard, see also the Declaration of European social partners on digitalisation, adopted on 16 March 2016, accessible at: https://www.businesseurope.eu/sites/buseur/files/media/position_papers/social/2016-03-16_tss_-_statement_on_digitalisation.pdf.

people with disabilities and other groups at risks of exclusion such as migrants, people living in remote areas and people living in poverty.

4.2 ***Encourage the development of AI tools and applications that are specifically targeted to help vulnerable demographics***, for instance through the organisation of open challenges or competitions. Resources should be devoted to yearly "AI for good" prizes, which reward the efforts to address key societal challenges, thereby tackling inequalities and ensuring that AI is deployed also to tackle problems which are experienced by a minority of the users, and are therefore seldom addressed by the market. AI should be developed with due regard to all grounds that are protected from discrimination in EU law, which also includes – as well as some of the grounds listed above – the prohibition of discrimination on the ground of sex.[14]

4.3 ***Establish a European Strategy for Better and Safer AI for Children***, in line with the European Strategy for a Better Internet for Children, designed to empower children, while also protecting them from risks and potential harm. The integrity and agency of future generations should be ensured by providing Europe's children with a childhood where they can grow and learn untouched by unsolicited monitoring, profiling and interest invested habitualisation and manipulation. Children should be ensured a free and unmonitored space of development and upon moving into adulthood should be provided with a "clean slate" of any public or private storage of data related to them.[15] Equally, children's formal education should be free from commercial and other interests.

5. MEASURE AND MONITOR THE SOCIETAL IMPACT OF AI

We need to understand the possibilities and limitations of AI systems as a means to build the future we want, and the impact they have on individuals and society – not only in the short but also in the long term.

5.1 ***Encourage research and development on the impact of AI on individuals and society***, including the impact on jobs and work, social systems and structures, equality, democracy, fundamental rights, the rule of law, human intelligence, the development of (cognitive skills of) children. Encourage conducting an evaluation of the societal impact of AI as a requirement in AI research and development in parallel with funding for the development of a particular AI system.

5.2 ***Support research and the development of tools to enable independent testing of AI systems by civil society organisations and other independent parties to inform individuals*** about the most trustworthy AI solutions in the market or used by public service providers.

5.3 ***Establish monitoring mechanisms at national and EU level to continuously analyse, measure and score the societal impact of AI.*** This can help us keep track of the positive and negative impact of AI on society and enable us to adapt or redirect strategies and policies on a continuous basis. A variety of indices can be considered to measure and score AI's societal impact such as the UN Sustainable Development Goals and the Social Scoreboard Indicators of the European Social Pillar. The EU statistical programme of Eurostat, as well as other relevant EU Agencies, should be included in this mechanism to ensure that the information generated is trusted, of high and verifiable quality, sustainable and continuously available. AI-based solutions can help the monitoring and measuring its societal impact.

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[14] See in this regard also Article 21 of the Charter of Fundamental Rights of the European Union: *Any discrimination based on any ground such as sex, race, colour, ethnic or social origin, genetic features, language, religion or belief, political or any other opinion, membership of a national minority, property, birth, disability, age or sexual orientation shall be prohibited.*

[15] This does not exclude the possibility for appropriate exceptions that are necessary in a democratic society and in full compliance with fundamental rights.

B. Transforming Europe's Private Sector

Despite the sizeable impact that European businesses expect from AI, only a small fraction of them use AI actively in industrial and commercial operations. This is particularly visible among small and medium enterprises (SMEs) that make up over 99% of Europe's businesses.[16] Furthermore, since SMEs account for 56% of Europe's total turnover, it is likewise important that larger companies in Europe accelerate their transformation.[17] In 2018, three quarters of European businesses did not adopt AI in any shape or form, just under a single quarter were in piloting and testing phases and reported difficulties of scaling, and only 2-3% of companies incorporated AI across their whole organisation.[18] A multi-stakeholder approach, bringing all actors around the table to join forces, is crucial to foster sectoral AI ecosystems where most of the transformative power of AI and sustainable growth is expected.

6. BOOST THE UPTAKE OF AI TECHNOLOGY AND SERVICES ACROSS SECTORS IN EUROPE

The adoption of AI is an important part of the digitalisation wave that European industries need to undertake in order to adapt themselves to the demands of the rapidly evolving digital economy. Policy-makers should foster their transformation, with particular attention to SMEs who form the important foundation of European economy. The uptake and acceleration of AI should happen both on the supply and demand side, through enabling policy and investment mechanisms.

6.1 Earmark significant resources in the InvestEU programme to support the transformation of European enterprises towards AI-enabled solutions. Such funding should be made available for companies of all sizes and in all sectors, and should focus on the uptake and incorporation of Trustworthy AI solutions.

6.2 Create an easy avenue for start-ups and SMEs to funding and advice. InvestEU, the European Innovation Council and other programmes, together with the network of Digital Innovation Hubs, should particularly help SMEs to define their AI transition plan and needs, propose attractive loans to finance their transformation, temporarily support the salaries of AI specialists to recruit, as well as financially supporting the re- or up-skilling of the workforce that is at risk of losing jobs or in need of a significant transformation of their jobs due to AI. This should also include support and advice on investment plans and intellectual property rights management.

6.3 Foster the availability of legal and technical support to implement Trustworthy AI solutions that comply with the Ethics Guidelines. The network of Digital Innovation Hubs should be exploited in this context, particularly to provide technical know-how to smaller companies who do not have the availability of sufficient resources and expertise for this purpose.

6.4 Encourage companies to form partnerships with training programmes addressing all levels of AI training (from data preparation technicians up to PhD level AI specialists), to ensure that the content of the programmes combine state-of-the-art science and technology with practical aspects of AI-enabler industrial systems (e.g. development and test methods, implementation and scaling, economics), to attract people with new skills, and to reskill their workforce so as to enable them to

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16 For more information, see the European Commission's latest annual report on SME's (2017-2018), accessible at https://ec.europa.eu/growth/smes/business-friendly-environment/performance-review_en.

17 See Eurostat statistics on small and medium-sized enterprises' total turnover in the EU.

18 See for instance Artificial Intelligence in Europe, Outlook for 2019 and Beyond, EY (2018); PwC's Global Artificial Intelligence Study: Exploiting the AI Revolution (2017), and Artificial Intelligence Innovation Report, Deloitte (2018).

work with AI systems. Incentivise private companies to invest in the re- and up-skilling of their existing workforce, for instance through the above-mentioned partnerships.

7. FOSTER AND SCALE AI SOLUTIONS BY ENABLING INNOVATION AND PROMOTING TECHNOLOGY TRANSFER

Next to university and institutional research, industrial research also plays a key role in fostering AI innovation, especially with regard to the transfer of technology into the market economy to the benefit of consumers or business users. Such innovation should be incentivised, for instance by establishing competitions, creating recognised standards and encourage open access on FRAND terms (fair, reasonable and non-discriminatory) to facilitate technology transfer. This can be achieved by increasing support for the emergence and growth of companies that provide AI enablers and solutions, or that necessitate new technology and skills to transform. This includes start-ups and scale-ups, SMEs and larger companies, as well as sector-specific ecosystems. The emergence and growth of AI companies in Europe producing and exporting high-tech products, and competing on a global scale should be supported. Particular attention should be given to Europe's strong position in the B2B segment, which contributes a significant part of the industrial value in Europe.[19]

7.1. Boost the development and growth of AI technology firms in Europe through the InvestEU programme. Those companies can also help drive the transformation of non-tech companies by supplying AI-enabled goods and services enabling efficiency gains and growth. Such funding should cover all stages of investments (from seed money for start-ups to larger scale A or B series investment, including growth investment) and enable Trustworthy AI solutions. In addition to fostering purely software-developing AI companies, we should also encourage SMEs that develop and manufacture AI-enabled hardware.

7.2. Facilitate the transition of AI solutions from research labs to testing environments and to commercial markets. Spin-offs from AI research labs should be encouraged in order to enable open innovation and create a market of AI technology firms as well as create an attractive European AI brand for talents outside academia. Guidance should be provided to ensure the participation of industry in research collaborations and R&D-based innovation more generally without undermining intellectual property rights, market competition and opportunities for global cooperation.

7.3. Create an EU-wide network of AI business incubators that connect academia and industry. This could be coupled with the creation of EU-wide Open Innovation Labs, which could be built further on the structure of the Digital Innovation Hub network.

7.4. Stimulate beneficial innovation by funding EU hackathons, competitions and industry challenge-driven research missions in AI across various sectors. This component should be strengthened in the Horizon Europe programme. Priority may be considered to research challenges, data and applications in B2B and P2C markets where Europe has a competitive edge to scale Trustworthy AI, and where disruptive changes could be created through substantial research efforts. In B2C segments, such competitions can also be steered towards applications ensuring a universal design approach and accessibility, and the development of AI products and services for creating social good. Such initiatives may act as strong attractors of top talents from Europe and around the world, and should be financed by substantial public funding (jointly by the European Commission and Member States), also with significant support by the industry.

[19] See Notes from the AI Frontier: Modelling the Impact of AI on the World Economy, McKinsey Global Institute, 2018.

8. SET UP PUBLIC-PRIVATE PARTNERSHIPS TO FOSTER SECTORAL AI ECOSYSTEMS

Individual companies form the nucleus of the economy. However, the biggest macro-economic impact is realised through economic networks or ecosystems. These ecosystems are comprised of different stakeholders, including companies of different types and sizes (end-user facing and subcontracting companies, start-ups, scale ups, SMEs, large companies) but also research institutions bringing latest innovation from lab to market, as well as the public sector (both as market actor and as policy-maker). We recommend that the uptake and scaling of AI systems in Europe be analysed and encouraged within the context of "enabling AI ecosystems".[20] This needs to occur on a sectoral basis to gain a sufficiently granular understanding of the specific needs and challenges raised within the ecosystem.

8.1 In the short term, conduct a sectoral-based in-depth analysis of several selected AI ecosystems. Identify the opportunities and challenges in those sectors in terms of beneficial impact that can be achieved with AI (for humans and society, private sector players, public sector players and in research) and identify the requirements to enable those opportunities in terms of data and infrastructure, skills building, governance and regulation as well as funding and investment. We propose to start this analysis in the second half of 2019 to better understand the specific needs of these sectoral AI eco-systems and to derive targeted recommendations both in terms of impacts to be achieved and enablers to be put in place.

8.2 In the medium term, set up Sectoral Multi-Stakeholder Alliances (SMUHAs) for strategic sectors in Europe to build their AI ecosystems with the relevant stakeholders. These Alliances – similar to the concept of Public Private Partnerships or PPPs – should bring together industry, research and academia, the public sector, civil society and user-focused organisations, as well as policy-makers to conduct a sector-based analysis of the challenges and opportunities generated by AI systems on a continuous basis. They should take concrete actions to meet the sector-specific needs in terms of targeted policies and enablers to tackle those challenges and opportunities.

C. Europe's Public Sector as a Catalyst of Sustainable Growth and Innovation

Europe has a strong public sector that can play a significant role when it comes to the uptake and scaling of Trustworthy AI and establishing a Single Market for Trustworthy AI in Europe. The EU's commitment towards the modernisation of public administrations was already confirmed by the Ministerial Declaration on e-Government adopted in Tallinn on 6 October 2017.[21] Deploying AI systems can help governments make better evidence-based policy-making decisions, deliver better services to individuals, groups and organisations by reducing internal costs,

[20] Enabling AI ecosystems can be viewed as "*collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solutions*". See R. Adner, Match Your Innovation Strategy to Your Innovation Ecosystem, Harvard Business Review 2006. Ecosystems function conceptually as a means to understand the relationships between different organisations or parties that share a common motive, technology, platform or knowledge base. The AI ecosystem members are likely to have developed and deployed AI technology in different ways, to different extents and for different purposes.

[21] Ministers in charge of e-Government policy from 32 countries of the European Union (EU) and the European Free Trade Area (EFTA) unanimously committed to the vision laid out in the EU e-Government Action Plan 2016-2020 and in the new European Interoperability Framework that public administrations and public institutions in the EU should be open, efficient and inclusive, providing borderless, interoperable, personalised, user-friendly, end-to-end digital public services to all citizens and businesses – at all levels of public administration. See https://ec.europa.eu/digital-single-market/en/news/ministerial-declaration-egovernment-tallinn-declaration.

increasing programme effectiveness, and enhance quality.[22] This should not lead to a lower quality of human relationships within public services or a reduction of such services; the very purpose of the contribution of AI systems in the public sector is to be human-centric, and lies in the facilitation of the tasks of civil servants to ensure better services to individuals.

Public services are critical to the relationship between the state and citizens, groups and individuals. AI has the potential to play a significant role in improving the quality and efficiency of public services, including empowering public servants, for example, through improving the accessibility and availability of information concerning public services. Given the capacity of AI services to operate at scale, at a highly granular level that can infer highly intimate information about individuals, these systems must be aligned with the concept of Trustworthy AI. For instance, the development and deployment of those systems should occur in a transparent and accountable manner, to ensure that they operate in ways that are consistent with the principles of good administration, respect for fundamental rights, democracy and the rule of law. More generally, governments have the crucial task to safeguard individuals' fundamental rights, to protect them from harmful uses of AI, and to protect the integrity of public institutions.

Today, the most advanced governments are increasingly providing application programming interfaces (APIs) to trusted intermediaries as a way to open up their infrastructure to private sector services and entrepreneurs, taking the role of Government-as-a-Platform (GaaP).[23] In this manner, the public sector can act as a catalyser for AI development in Europe. Through its role as a procurer, the public sector can also make use of public procurement strategies to not only incentivise the development and responsible innovation of AI systems for the public good, but also to promote responsible innovation and ensure such systems are trustworthy.

9. PROVIDE HUMAN-CENTRIC AI-BASED SERVICES FOR INDIVIDUALS

9.1 ***Deliver on the Tallinn Declaration on e-Government***[24] and put mechanisms in place to provide borderless, interoperable, personalised, user-friendly, and end-to-end digital public services to all individuals and businesses – at all levels of public administration. Consider adopting a proactive model for the delivery of public services for particular contexts and services in which they might enhance the effectiveness and quality of public services whilst ensuring due respect for fundamental rights and the rule of law.[25]

9.2 ***Where an AI-based service does not run properly or when an individual so requests, he or she should be able to interact with a human interlocutor, when there is a significant impact on the individual.***

9.3 ***Set up a single point of contact for individuals, for example by deploying natural user interfaces that can redirect individuals to the sought after information or service in an easily accessible***

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22 A good example is the European interoperability framework 2016-2020, but also the GOV.UK platform developed in the United Kingdom, the "building blocks" model trialled by the European Commission by DG DIGIT and the Estonian X-Road platform, which even moved in the direction of a decentralized architecture. In the US, for instance, Deloitte considers that "automation could save 96.7 million federal hours annually, with potential savings of $3.3 billion; at the high end, this rises to 1.2 billion hours and potential annual savings of $41.1 billion". However, the main objective is not to make savings by cutting jobs in public services.

23 O'Reilly, 2010, available at: http://chimera.labs.oreilly.com/books/1234000000774/ch02.html.

24 See footnote 21 above.

25 In Finland, the Aurora project which aims to bring such proactive services to currently undergoing a piloting phase, and the Finnish parliament has recently approved a law about the secondary use of data that contains the collection and combination of data for such purposes.

manner.[26] Public services should invest in conversational user interfaces that can meet the needs of individuals 24/7, serving them in a more agile, accessible and faster way, from a single point of contact. This could for instance be done through the use of chatbots or natural language interfaces with multilingual support, that can help individuals by redirecting them to the information or service that they seek, and that could also simplify the filling in of forms in a conversational manner. Feedback mechanisms that allow users to share their comments on the interfaces and thus help improving their AI models should be developed. Moreover, it must be ensured that such AI-enabled services are trustworthy, i.e. legal, ethical and robust.

9.4 Develop tools to ensure that public services can be deployed for all, and in a manner that safeguards individuals' fundamental rights, democracy and the rule of law. Access to public services through natural interfaces should be ensured for the entire population, regardless of capability (bearing in mind for instance the potential hurdle for the elderly to interact with those interfaces) or economic class. This also implies ensuring easy access for all to the internet, which today is still not a reality.[27] Moreover, individuals should always also be given the option to revert to a human interlocutor based on the principle of good administration.[28] Given the fact that some individuals may be unable to access or make use of AI-based digital services, there should be an option to revert to a human interlocutor.[29] Finally, it should be ensured that those services are provided without creating records of the request at an individual-identifiable level, and in a manner ensuring individuals' privacy.

10. APPROACH THE GOVERNMENT AS A PLATFORM, CATALYSING AI DEVELOPMENT IN EUROPE

10.1 Foster digitalisation by transforming public data into a digital format and continue collecting data that can be used to evaluate and improve public services as well as to develop new AI-based solutions. In case it concerns personal data, it should be ensured this happens in a manner that complies with privacy, data protection rules and other fundamental rights.

10.2 Provide data literacy education to government agencies. Public servants need to be educated on what data to prioritise, how it should be handled by prioritising quality, how to process it in a manner complying with relevant privacy and data protection rules, and how it can be used to boost competitiveness with data across industries in Europe

10.3 Create European large annotated public non-personal databases for high quality AI that are reliable and trustworthy. These should be accessible by legitimate stakeholders, including companies, civil society organisations and research institutes in Europe to develop and train AI solutions. Such non-personal data sets can not only help fostering AI development, but can also offer a remedy against false news by helping to preserve access to correct information. Foster the development of standards for interoperability of public applications and public data reservoirs.[30]

10.4 For procurement contracts on public services between a public sector organisation and a company, consider introducing a requirement that data produced in that context which does not infringe the

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26 The most commonly seen single point of contact for services is the information gateway eesti.ee of the Estonian government and can serve as a best practice example.

27 In this regard, it should be explored whether the role of public libraries could be exploited, turning them into as civil centres providing Internet access and staff helping people to use public digital services.

28 Following also the model of Article 41 of the Charter of Fundamental Rights of the European Union.

29 This is particularly important given that 44% of European citizens between 16 and 74 years do not have basic digital skills. See the European Commission Factsheet of October 2017 on Digital Skills, accessible at: https://ec.europa.eu/commission/sites/beta-political/files/digital-skills-factsheet-tallinn_en.pdf.

30 In this regard, the X-road protocol of the Estonian government can be considered as a best practice.

private company's IP and which is of general public interest should be handed back to the public sector allowing its reuse for beneficial innovation or building better services in full compliance with fundamental rights, the rule of law and democracy.

11. MAKE STRATEGIC USE OF PUBLIC PROCUREMENT TO FUND INNOVATION AND ENSURE TRUSTWORTHY AI

11.1 Within public procurement processes, allocate substantive funding to innovation-driven, AI-based solutions. This could function as a public sector instrument to fund innovative solutions, including AI-based solutions, created by start-ups, SMEs, scale-ups and larger companies.

11.2 Within procurement processes, ensure that potential risks of the use of AI by the government are identified, assessed and appropriately addressed. In order to safeguard individuals from risks, such as for instance privacy and personal data infringements, this could be done by mandatorily consulting the relevant authorities (including data protection authorities) prior to the procurement of AI systems, particularly in those contexts where there can be a significant impact on individuals' rights.

11.3 Introduce clear eligibility and selection criteria that in the procurement rules and processes of EU institutions, agencies and Member States that require AI systems to be trustworthy (lawful, ethical and robust), ensuring that they effectively protect people's personal data, privacy and autonomy. The Ethics Guidelines' assessment list can provide a helpful means to operationalise such requirement.

12. SAFEGUARD FUNDAMENTAL RIGHTS IN AI-BASED PUBLIC SERVICES AND PROTECT SOCIETAL INFRASTRUCTURES

Methods should be created to validate whether the government's decisions that rely on data-driven systems were biased against individuals compared to other similar decisions, given that access to one's own personal data is not enough to ensure the analysis of fair and just decisions that are in accordance with legal standards.

12.1 Ensure the application of the Ethics Guidelines for Trustworthy AI to AI systems deployed by the public sector.

12.2 Make available to any individual who is subject to an AI-informed governmental decision that produces legal effects or similarly significantly affects that individual, information on the logic of the algorithms and how data is used to inform such decisions, enabling the affected individual to understand, evaluate and potentially challenge the decision. Individuals should also receive an explanation about how each specific decision about them was reached, regardless of whether or not it was based on his or her personal data. Reference can also be made to the existing access to documents and information obligations resting upon authorities at national and European level

12.3 Fund and facilitate the development of AI tools that can assist in detecting biases and undue prejudice in governmental decision-making. Those tools could be made available to civil society organisations, NGOs, individuals and other interested parties that are questioning the integrity of public governance or are searching for support and evidence to challenge certain policies.

12.4 Ban AI-enabled mass scale scoring of individuals as defined in our Ethics Guidelines, and set very clear and strict rules for surveillance for national security purposes and other purposes claimed to be in the public or national interest in line with EU regulation and case law. Develop trustworthy ways to do this where legal, necessary and proportionate, and ensure that this is not used in ways to suppress or undermine (political) opposition or democratic processes.

D. Ensuring World-Class Research Capabilities

Europe must aim for scientific AI leadership, by focusing the power of its multi-faceted and distributed research excellence with several worldwide renowned Centres of Excellence to establish and demonstrate its intellectual and commercial leadership in AI. Both purpose-driven and fundamental research in all aspects of AI must be secured in order to promote AI that is trustworthy and to address relevant scientific, ethical, sociocultural and industrial challenges. In particular, research and innovation on AI that address complementarity between AI systems and humans, that foster Trustworthy AI solutions and that address societal challenges should be promoted. The overarching goal is to ensure world-class research that contributes to Europe's sustainability, growth and competitiveness, and inclusion, leading to individual and societal well-being. This necessitates a European research community that can unite through strong collaboration, and that can join forces with industry and society at large to build on European research strengths and enhance Europe's well-being.

13. DEVELOP AND MAINTAIN A EUROPEAN STRATEGIC RESEARCH ROADMAP FOR AI

Based on its strong basic and applied research record, Europe needs to develop an ambitious strategic research roadmap for AI, including an action plan to implement it.

13.1 The roadmap should include major open disciplinary and interdisciplinary fundamental scientific questions and grand challenges of global relevance, as well as major industrial and societal challenges where AI can be an enabler or a significant part of the solution. While basic research has a more general focus, the research needed to address industrial and societal challenges is mainly domain specific. Examples of important human-centric application domains especially beneficial to European society are the future of health, work, mobility and industry.

13.2 The roadmap should focus on areas of strategic value and opportunities, including the embodiment of AI into cyber-physical-systems and robotics, designing AI algorithms for chips to be deployed in the Internet of Things (IoT), the integration of reasoning and learning (or hybrid AI) to achieve learning systems that facilitate reasoning and explanation, resource aware learning even from small datasets, enabling digital twins and continuous learning, as well as techniques to enable Trustworthy AI.

13.3 The roadmap should in particular foster research that can help ensuring AI solutions that meet the Trustworthy AI principles and requirements, enabling for instance requirements such as human oversight, privacy-by-design, robustness, non-discrimination and transparency (including the traceability and explainability of AI systems). The roadmap should identify potential breakthrough findings and technologies that could come in the form of grand challenges of AI. Strategic breakthroughs should subsequently be translated into practice, allowing Europe to strengthen its competitive capacities.

13.4 The roadmap should be developed and regularly updated based on new developments in research and technology through a bottom-up process that complements the top-down policy-driven approach of governments and through stakeholder consultation. This roadmap also needs to identify impact in industry and society, and should harmonise and complement AI research roadmaps developed by Member States and other organisations.

13.5 While ensuring scientific independence, the roadmap should ensure for the needs and concerns of individuals through engagement with civil society representatives.

14. INCREASE AND STREAMLINE FUNDING FOR FUNDAMENTAL AND PURPOSE-DRIVEN RESEARCH

14.1 Provide dedicated, significant and long-term research funding for both fundamental and purpose-driven research on AI to maintain competitiveness of European research and companies, and to address relevant societal and industrial challenges. The funding should be aligned with the European AI research roadmap and should be independent of, and parallel to, any funding programme on ICT. Significant investment in basic funding is required to achieve adequate research independence, which is necessary for fundamental excellent research in AI.

14.2 Create incentives and support for interdisciplinary and multi-stakeholder research for example through large-scale challenge-driven research missions. While striving for technological leadership, ensure the involvement of social scientists, humanities scholars, as well as other interdisciplinary collaborations in European AI research projects. Increase permeability between disciplinary silos at universities and research institutions by easing admission to existing programmes and curricula from other disciplines and by establishing inter-disciplinary AI curricula and PhD programmes. Foster the involvement of civil society in AI research programme design and in projects (e.g. through citizen science) where appropriate.

14.3 Simplify and streamline the structure of research funding instruments. Reduce the overhead in efforts and time to decisions of applying for grants, for example through early reviews from abstract-sized submissions; improve the quality and consistency of proposal reviews, and increase the predictability of funding instruments and their timing to support long-term planning, using the European AI research roadmap.

14.4 Establish mixed academic-industrial transfer labs, mainly funded by industry, providing specific research for the companies while also providing funding for long-term open research and collaboration in the broader research area. The bridge between fundamental research and the application of its results in European organisations and on the market needs to be shortened. Specifically funded transfer projects are essential to achieve this objective. European AI research centres located in industrial environments should also be strengthened to create sufficient traction for building and growing the European AI start-ups ecosystem that can help commercialising cutting-edge research and technology.

14.5 Initiatives funded by the Horizon Europe and Digital Europe programmes related to AI should build in safeguards and conditions to ensure that public funding of these projects benefits the public interest. The funding should in particular support AI solutions that are in line with the Ethics Guidelines, and help fostering innovation in Trustworthy AI solutions. Funding of public research should be fully transparent, also taking into account indirect funding by interested parties through proxies. Whilst safeguarding scientific independence, civil society should be engaged in the management of the programmes, both at agenda setting level and at implementing or monitoring level. Enhanced trust in AI systems can be fostered by systematically including societal needs and concerns related to AI systems in the design and implementation phase of the respective EU research and funding programmes, such as Horizon Europe and Digital Europe, and the projects that will be funded thereunder.

15. EXPAND AI RESEARCH CAPACITY IN EUROPE BY DEVELOPING, RETAINING AND ACQUIRING AI RESEARCHERS

To facilitate world-class research, we need to create a stimulating and empowering research environment in Europe which attracts and retains researchers in AI. Research career prospects should be rich in opportunity and competitive to retain and attract international AI talent. Young researchers, in particular,

have to feel that Europe is where exciting, future-proof, sustainable, ethically aligned, and trustworthy AI is developed, and where an inspiring and fulfilling public or private research career is possible.

15.1 Acknowledge that a holistic strategy is needed to create the conditions for talents to find Europe attractive as a research environment, such as the availability of lively and vibrant research environments, stable and long-term funding, a critical mass of excellent researchers, competitive salaries, world-class infrastructure with unique datasets, competitive computing power and dedicated engineering support.

15.2 The work environment should offer collaboration between researchers and start-ups, larger companies and organisations, as well as society at large, encouraging researchers in academia to collaborate with industry and the public sector (e.g. through consultancy arrangements or secondments), including the possibility of split-time positions.

15.3 Create an open innovation culture through a lively, interdisciplinary and multidisciplinary research environment around world-class research centres. Enable and foster the creation of research-focused start-ups that develop translate and commercialise new AI products in Europe or can inject AI technology into existing products and services. Collaboration between research institutes and such start-ups should be enabled.

16. BUILD A WORLD-CLASS EUROPEAN RESEARCH CAPACITY

The European AI research community is based on distributed AI smaller research centres and laboratories widely spread across Europe, each with respective strengths ranging from specialised research and innovation domains up to large-scale and broad international regions. They engage in cutting-edge basic and applied research, connecting with local and international industrial and start-up partners and in particular, they attract young talents to the field of AI very early on. Europe is already home to a number of large centres of critical mass and high reputation (also embedded in international industrial ecosystems), which we refer to as Centres of Excellence (CoEs).

The full strength and diversity of Europe's AI community must be working together to address major grand challenges as well as scientific and technical breakthroughs. This requires a series of major capacity building initiatives. Such initiatives need to involve multi- and interdisciplinary expertise, connect and further develop existing Centres of Excellence, strengthen smaller research centres and laboratories to become Centres of Excellence, and provide specialised infrastructure for AI. This capacity should be balanced between distributed, local research and large-scale pan-European initiatives.

16.1 Strengthen and create additional Centres of Excellence (CoEs) that address strategic research topics and become a European level multiplier for a specific AI topic. These CoEs should receive specific funding in order to create a significant international impact in their areas of research, technology transfer and innovation. Moreover, while being interdisciplinary, these CoEs should have their own specific research focus.

16.2 Nurture and support Europe's AI research centres and laboratories through research funding to scale up to worldwide competition and help them strive to become Centres of Excellence. Such support includes specific fundamental and purpose-driven funding programmes, research professor funding, access to mechanisms to grow and the possibility to attract researchers of world-class quality and reputation.

16.3 EU institutions together with Member States should also create and fund networks consisting of AI Centres of Excellence, as well as smaller AI research centres and laboratories. These networks should form thematic focal points for AI research, attracting the top talents in their respective focus

areas with exciting research challenges and top infrastructure and support. Networks of centres with critical mass have a high potential to not only produce significant research results but to also create impact well beyond academic research.

16.4 Develop close collaborations with industry, the innovation ecosystem (e.g. DIH for AI and others) and other stakeholders that can provide feedback, pick up new results early on, and provide important additional funding. This collaboration must be based on an appropriate model for intellectual property rights and sharing of data and ideas.

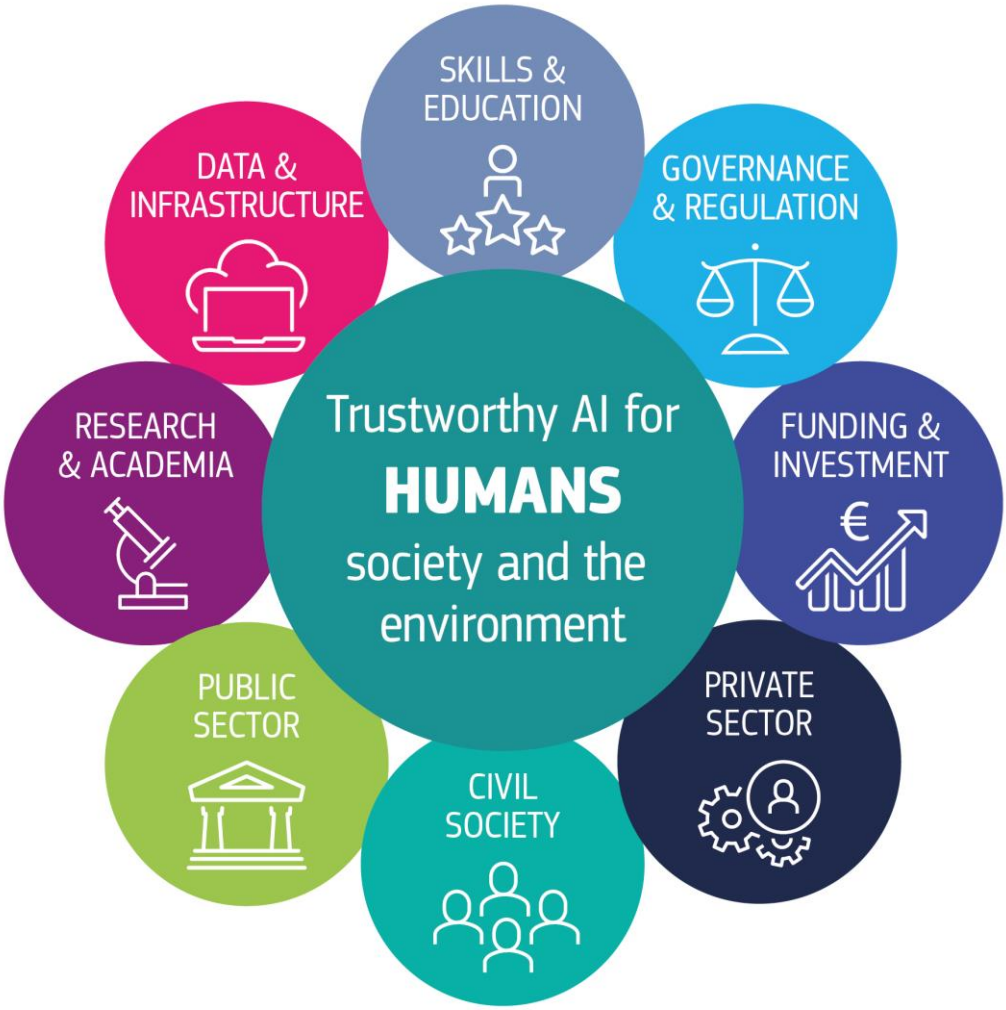
16.5 Create a dedicated Public-Private Partnership (PPP) in AI. It is critically important that this PPP does not compromise investment in local or Member States' initiatives in AI. The private and the public sector should be equal partners.

16.6 Develop a cross-cutting network focused on Trustworthy AI across European universities and research institutions. With the Ethics Guidelines published on 8 April 2019, Europe has taken a strong initiative to lead the global debate on the applied ethics of AI. Consideration should be given to support the development of a Centre of Excellence in Trustworthy AI to maintain Europe's intellectual leadership. The political institutions and the AI industry urgently need such word-class experts for newly emerging technology, legal, ethical and social issues, focusing in particular on the framework for Trustworthy AI put forward in the Ethics Guidelines. A cross-cutting network will provide a basis for research, teaching and disseminating AI ethics and other disciplines necessary to ensure Trustworthy AI across the whole European system.[31] It will support the coordination of activities relating to AI ethics and other relevant disciplines, which involve offering continuously updated curricula on these disciplines at all European universities. It also involves dissemination of research results to the wider public or organising public debates for civil society. To cover the multi- and interdisciplinary nature of AI research, the network should not become "siloed" but involve and integrate the technical, practical, philosophical, legal, economic, social and humanistic aspects of AI in various proportions depending on their specific research focus.

[31] The European University Association (which represents more than 800 universities and national rectors' conferences in 48 European countries) estimates that 720 professorial chairs in applied ethics will be needed for the network.

CHAPTER II

LEVERAGING EUROPE'S ENABLERS FOR TRUSTWORTHY AI



CHAPTER II. LEVERAGING EUROPE'S ENABLERS FOR TRUSTWORTHY AI

To achieve the impacts defined for each of the areas highlighted in Chapter I, the right foundation needs to be in place. Our foundational layer is described in terms of four enablers: (E) Data and Infrastructure, (F) Education and Skills, (G) a Governance and Regulatory framework and (H) Funding and Investment.

(E) Fostering the development and uptake of Trustworthy AI requires the availability of **data and a sound infrastructure.** This includes intense-computing infrastructure to enable the scale-out of Europe's AI ambition, both concerning digital AI segments and physical segments embedded with digital components. Edge computing provides a particularly interesting platform for scaling AI in a communications-efficient manner, which has many privacy-preserving advantages. Moreover, given that data is an indispensable raw material for developing AI, a safe, secure and high-quality infrastructure is needed that allows for the use and exchange of industrial and public data in a lawful, ethical and robust manner. Data donor schemes could be put in place to foster socially beneficial AI systems built on personal data, with the highest attention to privacy and data protection rules. Besides ensuring the necessary physical infrastructures, Europe should build a cloud infrastructure that can support the development and deployment of Trustworthy AI, and appropriate cybersecurity policies and expertise.

(F) Europe must invest in the development of human capital for artificial intelligence, fostering the necessary **skills and education** in an AI-enabled world. We must educate and develop the best scientific minds in AI, which requires a significant increase in the uptake of science and technology subjects at every level of the education system, and a substantial redesign of education systems from pre-school to higher education. Conscious and well-informed children and other individuals will create a solid foundation for responsible and positive uses of AI systems and digital technologies more generally, and strengthen their personal skills on cognitive, social and cultural levels. A doubling-down of efforts is needed to increase the number and proportion of women in science and technology. This will not only increase the available talent pool, but also foster the relevance and quality of research and innovation of AI systems for society as a whole. Finally, initiatives must be supported for upskilling and reskilling significant parts of the current workforce to provide them with the appropriate knowledge, skills, and attitudes in a transforming employment environment.

(G) Europe takes pride in its sound regulatory environment that enables and stimulates competition and innovation while safeguarding fundamental rights and protection from unacceptable risk or harm. Yet, the new challenges raised by AI require reflection on an **appropriate governance framework** and a review of the adequacy of the current **regulatory regime**, pursuant to a comprehensive mapping of relevant EU regulations and potential legal gaps to both maximise AI's benefits and prevent and minimise its risks. Such a review should generally be based on a risk-based approach to AI policy-making, and take into account both individual and societal risks. For unacceptable risks, the revision of existing rules or the introduction of new regulation should be considered. Finally, to achieve the impacts put forward in these recommendations, it is crucial to deliver on a European Single Market for AI.

(H) European Institutions and Member States, together with the private sector, must create a lucrative **funding and investment climate** for Trustworthy AI in Europe. Europe currently underperforms in terms of early stage innovation funding, as well as in investments in digital technologies and AI more generally. A concerted and integrated effort is needed to ensure that Europe can deliver on the benefits that AI can bring to individuals and society, requiring a full range of public funding mechanisms to be in place, and openness towards global competition. Besides foreseeing funding for the recommendations set out in this report, Europe must build an environment of trust whereby the private sector, jointly with all stakeholders, is motivated to invest in AI solutions and build the future that we want to create.

E. Building Data and Infrastructure for AI

Europe needs infrastructures capable of delivering secure, privacy-preserving data collection and storage, intense analytics, next-generation networks and software to support the development and delivery of AI systems at scale. This requires investment in infrastructure, data, software and networks.

17. SUPPORT AI INFRASTRUCTURES ACROSS MEMBER STATES

17.1 Invest in the necessary intense-computing AI architectures capable to scale-out the ambition for AI in Europe, including distributed clusters (cloud) and edge computing, large RAM and fast networks. Such large infrastructures must be supported in DIH networks, interconnected through high-speed networks. A number of strategically-focused infrastructures for simulation of physical models (digital twins) may be needed for some applications (manufacturing, automotive, etc.) where little data is available or too costly to produce (e.g. High-Performance Computing).[32] Engineering skills needed to develop and maintain such infrastructures must be developed and supported.

17.2 A network of testing facilities and sandboxes, with high-speed networks interconnecting them must be organised with appropriate governance mechanisms to set legal and ethical standards. AI Centres of Excellence (CoEs) can enable AI applications to be deployed and tested in "sandboxes" within well-defined conditions (see also Recommendation 29.2).

17.3 Invest in fundamental and applied research, innovation and industrial capacity building within edge-based intelligence, empowered by the interplay of hardware, software and AI capabilities. The increasing demand for connecting "things" and physical infrastructures, powered by next generation communication networks (5G) and edge-based compute infrastructure, open up high market potential for real-time, power efficient and privacy preserving AI where Europe can seize the opportunity as early adopter and position itself as the global leader for edge intelligence, particularly serving B2B and P2C markets. To leverage that, a favourable policy and investment environment for 5G roll-outs, large investment volumes in software toolchains for edge hardware design, compute infrastructure and distributed AI (also beyond Machine Learning) are needed for creating new unicorns in Europe, transforming large industries to digital locomotives and securing cutting-edge research and competence at a global scale. More prospective infrastructures will be needed in the longer term, to extend the capabilities of existing infrastructures, such as optical or quantum computing.

17.4 Liaise with EU actions and funding programmes based on the Electronic Leaders Group recommendations regarding dedicated AI co-processors (edge computing), jointly with digital microcontrollers initiatives, as well as optical and quantum computing. Foster the development of edge computing hardware with the European semiconductor industry. Support the dissemination, free of charge, of AI and IoT hardware and associated software tools towards European universities, engineering schools and the different start-ups and SMEs ecosystems. Edge computing is not an alternative to cloud-based AI, but an additional route for AI where Europe can have a competitive advantage with significant business impact across Europe concerning the proximity across Europe with different stakeholders.

[32] It is important to keep in mind that the models of HPC and AI applications often are different: HPC is mainly batch-based with very long run-times while AI applications often require interactive sessions with very many but relatively short runs.

18. DEVELOP LEGALLY COMPLIANT AND ETHICAL DATA MANAGEMENT AND SHARING INITIATIVES IN EUROPE

Data is an indispensable raw material for developing AI. With data volumes growing at 61% per annum[33], four times more data will be created until 2025 than that which exists today. Ensuring that individuals and societies, industry, the public sector as well as research and academia in Europe can benefit from this strategic resource is critical, as the overwhelming majority of recent advances in AI stem from deep learning on big data. A safe, secure and high-quality data infrastructure would enable Europe to better develop and train AI systems, which in turn can be steered towards applications that can facilitate the Sustainable Development Goals. A clear distinction must however be ensured between personal and non-personal data.[34] A fundamental rights-based personal data infrastructure as put forward in the GDPR should be fostered and its enforcement should be ensured. At the same time, the sharing of *industrial data* still poses a significant challenge, creating obstacles to collaboration between organisations and, in some cases, stifling innovation. Therefore, industrial and research solutions must be found for processing and sharing data in a secure and privacy-respecting way, allowing everyone to reap its benefits to the fullest.

18.1 Set up national and European data platforms for AI that include all necessary tools for data governance, annotation, and storage, next-generation networks, analytics software and, most importantly, datasets[35] through a structural and investment fund. European public data is currently found in silos across institutions and Member States, and should be gathered through secure platforms that comply with data protection rules. A structural and investment fund for a European data infrastructure should be considered, and appropriate governance mechanisms should be established. The Commission should support the coordination of data sharing and access through ecosystems, and thus leverage data as a competitiveness factor for European innovative and sustainable companies. Areas of particular focus should be: opening public funded data sources, redirecting funding flows to foster collaboration between public and private sector and policies to address regulatory barriers.

18.2 Consider European data-sharing infrastructures as public utility infrastructures. Data-sharing infrastructures should be seen as the basic building blocks of a society supported by AI technologies, creating trust and paving the way for companies to develop shared, trustworthy and interoperable data sharing platforms, with due consideration for privacy-, inclusion- and accessibility- by design.

18.3 Support an EU-wide data repository through common annotation and standardisation. This requires investment in the development of methods and tools that render datasets comparable and useable across EU borders. The development of domain-specific data representation should be considered, as well as standards specific to particular domains. Standardised data and machine learning parameter schemes can help ensure a common data format that allows combining diverse datasets in the public domain. An EU system for annotating datasets and standardisation should be specifically supported in high impact domains with particular domain-specific content (such as employment, manufacturing or health).

18.4 Support research on and development of industrial solutions for fast, secure and legally compliant industry data sharing (e.g. encryption) and stimulate sharing of industry data. Avoid data

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[33] See for instance: https://www.networkworld.com/article/3325397/idc-expect-175-zettabytes-of-data-worldwide-by-2025.html.

[34] As for instance initiated in Regulation (EU) 2018/1807 on the free flow of non-personal data, applicable since 28 May 2019.

[35] This should build on the Directive on the re-use of public sector information, also known as the 'PSI Directive' (Directive 2003/98/EC, which is currently under revision.

monopolies by supporting companies that contribute to a sustainable ecosystem. Incentives could be provided for creating consortia around verticals to share data in a legally compliant manner, contributing to European infrastructures or datasets, or doing research for improving such infrastructures. Data-sharing mechanisms should be ethical and in compliance with EU data protection law.

18.5 Foster the creation of trusted data spaces[36] for specific sectors (e.g. healthcare, automotive and agri-food) where actors in a given value chain accept to share data, yet the rights related to the data rest with end users and/or the stages of the value chain where most of the value is being created. Industrial policy can help specify sector specific openness and non-discrimination requirements for access to trusted data spaces, and clarify the conditions under which inter-firm data-sharing cooperation should respect competition rules, particularly in terms of membership requirements, type of data shared, and access conditions for third parties. It should also determine how intellectual property frameworks impact the allocation of property rights within trusted data spaces.

18.6 Develop mechanisms for the protection of personal data, and individuals to control and be empowered by their data, thereby addressing some aspects of the requirements of trustworthy AI. Tools should be developed to provide a technological implementation of the GDPR and develop privacy preserving/privacy by design technical methods to explain criteria, causality in personal data processing of AI systems (such as federated machine learning). Support technological development of anonymisation and encryption techniques and develop standards for secure data exchange based on personal data control. Promote the education of the general public in personal data management, including individuals' awareness of and empowerment in AI personal data-based decision-making processes. Create technology solutions to provide individuals with information and control over how their data is being used, for example for research, on consent management and transparency across European borders, as well as any improvements and outcomes that have come from this, and develop standards for secure data exchange based on personal data control.

18.7 Create a data donor scheme, allowing individuals to donate data for specific purposes, surrounded by clear governance and transparency, and safeguards for privacy protection.

18.8 Consider the introduction of a data access regime on FRAND terms**,** namely fair, reasonable, and non-discriminatory. In addition, data interoperability amongst market players should be incentivised and required, where appropriate. In specific market circumstances, data accumulation by one or more firms can raise barriers to entry. In such contexts, data portability rights may not be enough, and more far-reaching interoperability requirements can help promote competition and innovation by new entrants, while however respecting legal obligations and rights. In contemporary competition law, interoperability requirements can only be applied on dominant firms upon proof that data access is indispensable to compete. Yet there may be circumstances in which sector specific regulatory frameworks should go further, by laying down horizontal interoperability

[36] See also Data Trusts: A New Tool for Data Governance, by Nesta and Element AI (2019), available at: https://hello.elementai.com/rs/024-OAQ-547/images/Data_Trusts_EN_201914.pdf. Recently, the Canadian government recognized data trusts, a third party stewardship model, as an "emerging solution" that could provide a secure and privacy-enhancing means of sharing data in order to spur the development of AI innovations in a broad spectrum of the economy. Canada considers that data trusts could allow for greater sharing and use of data for socio-economically beneficial purposes within a framework that protects against abuses of that data. It considers that data trusts could benefit research communities in areas such as health, clean technology or agri-business, among others. The United Kingdom is itself engaged in data trust pilot projects. Europe should explore its own initiatives in this area to facilitate data sharing for research purposes and foster innovation.

obligation on both dominant and non-dominant firms to facilitate the emergence of competitive market structures.

19. SUPPORT EUROPEAN LEADERSHIP IN THE DEVELOPMENT OF AN AI INFRASTRUCTURE

Digital dependency on non-European providers and the lack of a well-performing cloud infrastructure respecting European norms and values may bear risks regarding macroeconomic, economic and security policy considerations, putting datasets and IP at risk, stifling innovation and commercial development of hardware and compute infrastructure for connected devices (IoT) in Europe. Without focusing on Europe exclusively, we believe it is important to foster the development of such infrastructure also in Europe.

19.1 Support the development of open source AI software libraries including the Trustworthy AI guidelines and in line with the latest achievements in research. By properly supporting the development of such AI libraries, building on strong European competence, companies and researchers will be able to use up-to-date software, offered by software providers operating in Europe, providing support and training, which will also help increasing competitiveness of European companies in this field. Support dedicated training on such AI software through the AI Digital Innovation Hub (DIH) network.

19.2 Support mechanisms for cutting-edge research, innovation and commercial development of hardware and compute infrastructure for connected devices and the Internet of Things (IoT) in Europe. A dedicated budget line in the Digital Europe programme for this purpose could be considered. Consideration should be given to developing a European champion that can provide cloud services with the option to maintain its datasets within Europe. We envisage cases whereby, for certain types of data, an option to guarantee that the data is stored in Europe might be appropriate.

20. DEVELOP AND SUPPORT AI-SPECIFIC CYBERSECURITY INFRASTRUCTURES

The AI specific cybersecurity policy should be formulated to be user centric, systemic, and anchored in open and pluralistic process. User centric cybersecurity policies must protect users' rights online, by design and by default. New attacks appear which directly target the AI module in AI-based applications, while AI can help fighting cyberattacks.

20.1 Develop an infrastructure for cybersecurity, building on the Cybersecurity Act adopted by the EU in spring 2019 to protect our networks, data, and users from risks. Holistic digital security approaches should address the risk of malware and vulnerabilities, social engineering, restrictions on the functionality of network, efforts to weaken the integrity of communications systems, and threats to anonymity, privacy, and other human rights exercised online. Develop an ecosystem for producing AI techniques allowing Member States to deploy their defence against cyberattacks. We acknowledge the important role that ENISA has to play in this context.

20.2 Develop user-centric AI cybersecurity policies to protect users' rights online. AI-specific cybersecurity policy should be formulated to be user-centric, systemic, and anchored in open and pluralistic process. Cybersecurity policies that focus excessively on state operations undermine international human rights obligations, threaten the peaceful use of the internet, and inhibit the free flow of and access to information. Fora where cybersecurity policies are formulated should involve effective participation of all stakeholders, granting equitable access to documents and decision-makers as well as designated opportunities for input and reporting.

20.3 Adopt holistic digital security approaches to address the risk of malware and vulnerabilities, restrictions on the functionality of network and other efforts to weaken the integrity of our societal infrastructures.[37] This could for instance be done by encouraging EU hackathons and competitions that can help analysing the penetrability of IoT devices against cyberattacks. Build inherently robust systems and respective processes that on top of cyber hygiene requirements also implement methods and techniques prepared for "unknown unknowns" by monitoring systems behaviour and applying advanced analytics for better situational awareness and response. Close vulnerabilities such as "paths of least resistance" by focusing on the overall system and on how the system level security-by-design is implemented. Apply red-teaming, ensuring that the attacks are designed to be representative of what an actual attacker would do, considering the domain specific and generic features. In some cases, a responsible disclosure of weaknesses should be used to pressure operators to abandon defective practices (e.g. vulnerabilities that expose computer systems).

20.4 Invest in AI-enabled cyber protection systems. The time for implementing such systems in practice should be shortened, allowing for efficient monitoring and triage of events, incidents and more generally the behaviour of various control systems. AI techniques can be used to filter false-positives and the disruption of services, and provide predictive measures. The notion of zero-day type of attacks should be extended from the cybersecurity field to the general field of AI-based systems, with the specifics of intrinsic new types of vulnerabilities and potential targeted areas, such as training datasets, knowledge bases, algorithms and reasoning mechanisms. Consider repositories for sharing trusted info about vulnerabilities and exploits in AI systems, similar to those widely used and supported in the cybersecurity field.

20.5 Beyond safeguarding public infrastructures, ensure that the entire data transmission system is more secure. Since an increasing amount of data is transferred within IoT networks, security concerns on transmitting sensitive business data across these networks are rising. Traditional IoT settings, where data is stored and analysed in a centralised cloud or data centre, are also vulnerable to well-coordinated cyberattacks and power outages. This requires a holistic approach towards electricity and electronic networks that can be spurred by governments.

F. Generating appropriate Skills and Education for AI

The development of AI systems in Europe requires a massive input of human intelligence. Europe needs more talents to lead ambitious fundamental word-class research programmes and retain them with attractive research and working conditions. Therefore, the attraction of talent into the fields of science and technology is of paramount importance to ensure Europe's innovativeness in the long run. Furthermore, in the future, AI systems will augment and complement human capabilities in hybrid work settings. Practitioners in all areas will need to be upskilled with digital competences to be enhanced in their roles. At the same time, the future workforce will have to be equipped with a new – human centric – set of skills that empowers them on a cognitive and a socio-cultural level face the challenges ahead.

[37] Two examples can be put forward in this regard. A first example concerns NotPetya, whereby an estimated $10 Billion of damages occurred through a combination of "EternaBlue" (a leaked US NSA penetration tool) and Mimikatz (a proof of concept to demonstrate security fault by a French security researcher deployed from Russia to Ukraine that spread over the world and even back to Russia). A second example concerns the life threatening attack against Schneider's Triconex controllers in a petrochemical plant in Saudi Arabia. The attack was diverted, but it was found that instead of just shutting down the plant or destroying data, it was aimed to trigger an explosion that would have cost lives.

This will require also a deep-reaching change in education systems. Although skills and education are domains that fall to a large extent under Member States national and often even regional competences, the European Commission should participate in this effort to trigger these fundamental changes in national educational systems and support activities to share experiences and best practices and to seize common opportunities. A wide-ranging and long-term action plan should be carried out, involving actors at all levels. This calls for the adoption of a multidisciplinary approach that mobilises various education and training stakeholders including education institutions at all levels, social partners, training providers, community colleges and companies, which will also have to shoulder parts of the AI upskilling and reskilling requirements.

21. REDESIGN EDUCATION SYSTEMS FROM PRE-SCHOOL TO HIGHER EDUCATION

As AI is deployed more extensively and more intensely, there will be a strong need to educate everyone, starting from an early age, in digital literacy, coding and STEM. Digital literacy is already being implemented in formal education in various forms as well as in more informal awareness initiatives across Member States and in pan-European contexts. These needs to be further supported and developed when it comes to AI development. Importantly, complementary cognitive, socio-cultural and interdisciplinary skills will empower individuals and enable the mastery of sectoral knowledge in combination with new technological solutions. Thus, education systems have to prepare people not only with digital skills but also by strengthening people's human-centric skills. Here, educators should receive specific attention, since it is in their hands to prepare for the upcoming challenges. The DigCompEdu[38] framework of the European Commission already provides here a valuable reference frame.

21.1 ***Set up recommendations and incentives to adapt national education systems to strengthen children in human-centric key skills***: (i) cognitive competences like problem solving, process and quality monitoring, critical thinking, judgement and creativity, etc. (ii) socio-cultural competences like empathising, leading, persuading, envisioning, etc. (iii) entrepreneurial and innovation competences.

21.2 ***Besides fostering the development of skills in a holistic manner throughout different disciplines in the education system, embed mandatory ICT and digital literacy classes*** (i.e. responsible and positive use of AI systems and digital technologies, including awareness for better-internet-for-kids) in formal primary and secondary education. Emphasise gender-sensitive real-life applications for digital skills, incorporating project-based learning and hands-on experience.

21.3 ***Direct the DigCompEdu Framework towards educators at all levels of education.*** This should happen from early childhood to higher and adult education, including general and vocational education and training, special needs education, and non-formal learning contexts and ensure accessibility to learning resources and activities, and for all learners (based on universal design and accessibility standards).

21.4 ***Recommend Member States to require gender competences for STEM educators in the hiring process in formal education systems.*** More generally, set incentives to offer gender sensitivity trainings for STEM educators.

[38] The European Framework for the Digital Competence of Educators (DigCompEdu) is a scientifically sound framework describing what it means for educators to be digitally competent. It provides a general reference frame to support the development of educator-specific digital competences in Europe. DigCompEdu is directed towards educators at all levels of education, from early childhood to higher and adult education, including general and vocational education and training, special needs education, and non-formal learning contexts. For more information, see: https://ec.europa.eu/jrc/en/digcompedu.

21.5 Support dedicated initiatives that encourage young people to choose AI subjects and related fields as a career. Provide sustained substantial incentives and funds for initiatives that focus on closing the "self-efficacy gender gap" in primary and secondary education systems. Target a proportion of 50 % of female talents enrolling subjects like natural science, STEM and ICT in secondary and higher education by 2030.

21.6 Support the implementation of educational AI technologies in primary and secondary education to facilitate individual learning requirements (e.g. cognitive, AI-based tutoring) [39]. The use of AI systems in education should strictly comply with fundamental rights, with due account for the vulnerable position of children.

21.7 Develop and offer career guidance services (e.g. recommender systems) to support people in finding and choosing education offers based on their individual skills (gaps).

22. DEVELOP AND RETAIN TALENT IN EUROPEAN HIGHER EDUCATION SYSTEMS

A lack of AI-related skills (including technical AI skills, skills for dealing with AI and managerial capabilities to extend AI in business) has been identified as the most important barrier to AI adoption in Europe.[40] AI talents with expert knowledge are required who are capable of driving, managing and conducting AI activities in their institutions and organisations. The creation of an excellent innovation environment necessitates not only on funding. Europe also needs to attract, develop and retain a comprehensive talent pool of AI-developers, entrepreneurs and data analysts, and to create a beacon for talent. This will require dedicated efforts in establishing cross-disciplinary AI curricula in tertiary and post-graduate education which integrate ethics, humanities and technical disciplines, in mainstreaming AI-related skills in all academic disciplines and professional fields, as well as in fostering cooperation spaces between AI experts and professionals.

22.1 Develop and implement a European Curriculum in AI in collaboration with the European Excellence Centre of Trustworthy AI as proposed under Recommendation 16, to incorporate applied ethics of AI and to ensure an interdisciplinary and multidisciplinary perspective through cooperation across technical, humanist, social sciences, legal and philosophical approaches to AI.

22.2 Implement interdisciplinary PhD schools and Post-PhD programmes in AI (including humanities, social sciences and ethics) in member state universities which closely collaborate with European AI research hubs. Provide financial scholarships for students to participate in such dedicated PhD programmes and post-PhD programmes and include these programmes in calls for AI Excellence Centres. To assure a certain quality across Europe, those training courses and studies could be certified.

22.3 Increase disciplinary mobility between AI associated curricula. This can be done through streamlined admission policies of universities to allow for permeability between disciplinary silos and enable hybrid qualification of talent and interdisciplinary research and development. Implement credit accumulation models to receive AI-related degrees.

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[39] See Ritter, S., Anderson, J. R., Koedinger, K. R., & Corbett, A. (2007). Cognitive Tutor: Applied research in mathematics education, in Psychonomic Bulletin & Review, 14, Paaßen, B., Gallicchio, C., Micheli, A., & Hammer, B. (2018), Tree Edit Distance Learning via Adaptive Symbol Embeddings; and Stamper, J. C., & Koedinger, K. R. (2011). Human-machine student model discovery and improvement using DataShop. In International Conference on Artificial Intelligence in Education (pp. 353-360). Springer, Berlin, Heidelberg.

[40] See Notes from the AI Frontier: Tackling Europe's Gap in Digital and AI, McKinsey Global Institute, 2019.

22.4 Mainstream and include skills related to data and AI in all academic disciplines and professional fields to increase the potential of areas where AI applications can be developed. This includes the development of a state-of-the-art MOOC (Massive Open Online Courses) for AI, including elementary training on the basics as well as on relevant special topics, coupled with decentralised (regional) face-to-face training activities at universities. The Commission should consider the creation of an EU-wide MOOC on AI, accessible to all European citizens in all EU languages. All such programmes should ensure the concept of accessibility and universal design to include all sectors of society and to leave no one behind.

22.5 Foster cooperation spaces between AI researchers and professionals. Encourage universities to increase their activities in AI training for professionals and the creation networks of universities, vocational schools and companies to build living lab infrastructures (e.g. pilot and IoT training factories), in which universities, vocational schools and companies develop a common training concept.

22.6 Support the implementation of postgraduate and supplement curricula on entrepreneurship and innovation with a focus on digital economy and data-driven innovation to support continuous learning. This also includes the establishment of a network and digital platform to exchange, optimise and manage those (regional) training activities.

22.7 Extend existing programmes like ERASMUS[41], European Schoolnet[42] and e-twinning[43] to AI. This creates synergies and allows to access existing know-how, networks and infrastructure.

23. INCREASE THE PROPORTION OF WOMEN IN SCIENCE AND TECHNOLOGY

Today, only 12% of leading machine-learning researchers are female.[44] Empirical evidence shows that despite the growing demand of ICT specialists and digital profiles, the percentage of Europeans with ICT-related education is decreasing.[45] Compelling evidence of the impact of gender stereotypes is the "self-efficacy gender gap" which is basically non-existent (or even reversed in favour of girls) at the primary and lower secondary education levels, but starts to be measured in secondary levels and becomes even more pronounced at the tertiary level.[46] Furthermore, the prevalence of male norms and networks in science and technology professions disadvantage women in informal selection and promotion processes.[47] As a consequence, Europe is currently not exploiting its talent pool, causing an annual productivity loss. For instance, in ICT-related industries only, this loss extends to EUR 16.2 billion for the European economy to

41 The European Union's Erasmus+ programme is a funding scheme to support activities in the fields of Education, Training, Youth and Sport. For more information, see https://eacea.ec.europa.eu/erasmus-plus_en.

42 European Schoolnet is the network of 35 European Ministries of Education, based in Brussels, bringing innovation in teaching and learning to Ministries of Education, schools, teachers, researchers, and industry partners. For more information, see: http://www.eun.org/home.

43 eTwinning offers a platform for staff (teachers, head teachers, librarians, etc.), working in a school in one of the European countries involved, to communicate, collaborate, develop projects and share. For more information, see: https://www.etwinning.net/en/pub/index.htm.

44 UNESCO Report (2019): "I'd blush if I could – Closing Gender Divides in Digital Skills through Education", access: https://unesdoc.unesco.org/, last access 03.06.2019.

45 Quirós, C. T., Morales, E. G., Pastor, R. R., Carmona, A. F., Ibáñez, M. S., & Herrera, U. M. (2018). Women in the digital age. European Commission. Retrieved from https://ec.europa.eu/digital-single-market/en/news/increase-gender-gap-digital-sector-study-women-digital-age.

46 Fraillon, J., Ainley, J., Schulz, W., Friedman, T. and Gebhardt, E (2014): Preparing for Life in a Digital Age: The IEA International Computer and Information Literacy Study International Report. Amsterdam, international Association for the Evaluation of Educational Achievement.

47 Haas, M., Koeszegi, S.T., and Zedlacher, E. (2016): Breaking Patterns: How Female Scientists Negotiate their Token Role in their Life Stories, Gender Work and Organization, Vol. 23 (4), pp. 397-413, doi:10.1111/gwao.12124.

women leaving their digital jobs to become inactive.[48] An increased proportion of women in science and technology will increase the relevance and quality of research and innovation outputs for society as a whole.[49] Consequently, closing the gender gap in digital skills requires aggressive and sustained efforts.

23.1 ***Prioritise gender equality and gender mainstreaming*** in all AI policies by also making use of gender budgeting tools and the implementation of gender quota where appropriate. Target a proportion of female talents of at least 30 % in AI higher education, AI workforce and AI eco-systems by 2030.

23.2 ***Attract female talents into the field of AI and related subjects*** through sustained, dedicated and substantial funding programmes and attractive scholarships based on inclusive practices (including intersectional approaches)

23.3 ***Sponsor initiatives for networking and coaching for Women in AI.*** The importance of networking, coaching and meeting role models has been emphasised repeatedly in the literature on women in science and technology fields. Thus, it is essential to establish and fund AI mentorship programmes as well as to create safe spaces for women and girls both within and outside the formal education sectors to support and encourage women in AI careers.

23.4 ***Incorporate humanities, social sciences, and gender research into AI research programmes*** to increase diversity and guarantee a multidisciplinary approach.

23.5 ***Address gender bias in algorithmic decision-making***, e.g. in the hiring funnel, institutionalized biases are particularly difficult to track. Address the fact that AI implementation specifically affects women (professions) in labour markets. More research is needed to understand the impact on traditionally "female" jobs.

24. UPSKILL AND RESKILL THE CURRENT WORKFORCE

The Future of Jobs Report of the World Economic Forum[50] forecasts a substantial reskilling need for every second employee within the next four years. Education and training thus have to be at the centre of the implemented strategies to enlarge the talent pool for Europe. Continuous training measures will play a key role in helping people to anticipate, adapt, upskill, retrain and take advantage of the opportunities presented by new AI-related activities as part of broader career support mechanisms. Continuous learning activities and vocational education have to be supported to cope with the challenges of digital skills, as well as the new social and behavioural skills needed in a human-machine working environment.

24.1 ***Create a right to continuous learning for all and implement it by law and/or collective agreements.*** Adapt continuous learning systems to equip workers with both tech-related and personal skills, and introduce a work-life-train balance. This includes the need for strong career guidance and professional development for workers whose job is threatened by automation with important

[48] See footnote 44 above.

[49] Diversity research has established that in general diversity increases problem solving capabilities and decision quality, performance and innovation. See Schneider, J., & Eckl, V. (2016). The difference makes a difference: Team diversity and innovative capacity. Mimeo, Gender Diversity Impact (GEDII) (2018): Project Deliverable D4.3 Survey Analysis and Performance Indicator. Research Report. Online available at: https://www.gedii.eu (checked: 19.07.2018); Hoisl, K.; Gruber, M. and Conti, A. (2017): R&D Team Diversity and Performance in Hypercompetitive Environments. In: Strategic Management Journal 38 (7), 1455-1477; Lorenzo, R.; Voigt, N.; Schetelig, K.; Zawadzki, A.; Welpe, I.; Brosi, P. (2017): The Mix That Matters. Innovation Through Diversity. Online available at: https://www.bcg.com/dede/publications/2017/people-organization-leadership-talent-innovation-through-diversity-mix-that-matters.aspx (checked: 19.07.2018); Østergaard, C.R.; Timmermans, B.; Kristinsson, K. (2011): Does a different view create something new? The effect of employee diversity on innovation. In: Research Policy 40 (3), 500-509; Schneid, M.; Isidor, R.; Steinmetz, H.; Kabst, R. (2016): Age diversity and team outcomes: a quantitative review. In: Journal of Managerial Psychology 31 (1), 2-17.

[50] World Economic Forum, The future of Jobs (2018), accessible at: http://reports.weforum.org/future-of-jobs-2018/preface/.

training entitlements and the development "professional passports" to ensure the portability of skills.

24.2 ***Define critical skills in sensitive areas with human safety and security critical implications and create measures against skill deterioration. Address undesirable de-skilling of workers through AI, in particular in operations or processes that require human oversight or intervention.*** Promote and support the development of new skills transfer and acquisition programmes to enable workers made redundant or faced with the threat of redundancy due to automation and increased AI take-up to acquire new skills that will enable them to seek new forms of employment as the structure of the labour market is reshaped in response to the turn to increased reliance on digital services and processes.

24.3 ***Develop employment policies that support and reward companies who are setting up strategic up- and reskilling plans for the development of new data and AI-related applications.*** Encourage organisations to conduct a strategic workforce planning including a plan for existing workforce to upskill towards AI, also with potential support from universities and consultancies. Employers should refrain from introducing new technologies with a disrupting impact on jobs without having initially properly worked on reskilling plans and alternatives for workers.

24.4 **Upgrade the European Computer Driving License (ECDL) to an AI Driving License.** The ECDL is a computer literacy programme supported by the ECDL Foundation.[51] Europe should develop a similar syllabus and certification scheme for artificial intelligence.

25. CREATE STAKEHOLDER AWARENESS AND DECISION SUPPORT FOR SKILLING POLICIES

The enormity of these educational tasks calls for a number of social innovations, provided through a multi-stakeholder model. Governments, social partners (employers and trade unions) and vocational education and training providers are, in Europe, the main stakeholders defining training priorities, ensuring cross-sectoral and sectoral funding, and delivering trainings to workers. These stakeholders need to be aware of, and be up to date with, the effects of AI on job markets. Furthermore, they have to be provided with appropriate decision support and in order to be able to pro-actively design effective policy measures.

25.1 ***Increase the knowledge and awareness on AI within EU and national policy-making institutions.*** This will help them to make well-reasoned policy decisions. Moreover, effective oversight of regulated entities deploying AI-enabled tools will also require that supervisors are equally knowledgeable about AI and aware of the developing trends in their respective regulatory perimeter. One method to achieve this is through setting digital affairs committees in national parliaments gathering politicians with diverse backgrounds including AI experts.

25.2 ***Foster the development of advanced skills and jobs forecasting algorithms to anticipate and timely address changes on the job market.*** This will allow the forecasting of job- and skills disruption across numerous sectors, and enable organisations, policy-makers and unions to collaborate on re- and up-skilling programmes and for workers. At the same time, it can help addressing one of the biggest challenges of the digital era, namely job insecurity and anxiety for the future generations.

25.3 ***Reinforce or develop strong training and career guidance systems that support workers affected by technological disruption.*** Monitor changes in labour markets and make the European Social Fund and the European Globalisation Adjustment Fund (EGF) more responsive by dedicating more programmes to up-skilling strategies and making EGF intervention more preventive and less

[51] For more information, see: http://www.ecdl.org.

curative. Furthermore, maintain digital skills and job coalition initiatives that match workers and companies seeking their skills and encourage the creation of tools allowing employees to conduct a "self-assessment of employability", so that they can map and visualise their competences.

25.4 ***Include critical and ethical awareness of AI in existing European awareness initiatives and networks***, such as those under the pan-European Better Internet for Kids programme. In addition, promote critical vigilance to industry interests in such awareness programmes.

25.5 ***In public procurement processes of AI-enabled technology for education, include an assessment of embedded interests, ethics and social impacts.*** Such products should not be deployed ad hoc in educational settings based on the free availability or promotional access to educators or institutions, but must be based on an assessment of their ethical implications and the commercial or other embedded interests/possible trade-offs between interests. Promote critical and ethical awareness of available AI technology products used in education by educators and educational institutions and consider developing a standard for AI tools in education built on the seven key requirements for Trustworthy AI as developed in our Ethics Guidelines.

G. Establishing an appropriate governance and regulatory framework

Ensuring Trustworthy AI necessitates an appropriate governance and regulatory framework. By appropriate, we mean a framework that promotes socially valuable AI development and deployment, ensures and respects fundamental rights, the rule of law and democracy, while safeguarding individuals and society from unacceptable harm. On 8 April 2019, we published our Ethics Guidelines that set out three components for Trustworthy AI: (1) lawful AI, (2) ethical AI and (3) robust AI. The Ethics Guidelines only deal with the two latter components, yet the first is equally crucial. Many of the principles set out in the Guidelines reflect existing EU law. This section complements the Guidelines by providing guidance on appropriate governance and regulatory approaches beyond voluntary guidance.

We acknowledge that ensuring an appropriate framework that maximises the benefits of AI and that prevents and minimises its risks is no easy task. Europe takes pride in its sound regulatory environment that enables and stimulates AI development and deployment through fostering legal certainty and providing a distinct global competitiveness element, while at the same time safeguarding fundamental rights and protecting individuals and society from risk or harm, guided principally by the proportionality principle. Yet to deliver trustworthy AI for Europe, independent and meaningful oversight mechanisms need to be established, and an expansion of the institutional capacities, expertise and instruments of policymakers is needed. Yet little evidence is available to inform policy-making, due to the novelty of the technology, the lack of thorough and systematic understanding of its impacts and associated business models, and the unpredictability of its uptake, development and evolution even in the short term. Bearing this in mind, here below we propose a number of recommendations that should already be considered by policy-makers at EU and national level.

26. ENSURE APPROPRIATE POLICY-MAKING BASED ON A RISK-BASED AND MULTI-STAKEHOLDER APPROACH

26.1 ***Adopt a risk-based approach to regulation***. The character, intensity and timing of regulatory intervention should be a function of the type of risk created by an AI system. In line with an

approach based on the proportionality and precautionary principle, various risk classes should be distinguished as not all risks are equal.[52] The higher the impact and/or probability of an AI-created risk, the stronger the appropriate regulatory response should be. 'Risk' for this purpose is broadly defined to encompass adverse impacts of all kinds, both individual and societal.[53]

26.2 ***For specific AI applications that generate "unacceptable" risks or pose threats of harm that are substantial, a precautionary principle-based approach should be adopted instead.***[54] Regulatory authorities should adopt precautionary measures when scientific evidence about an environmental, human health hazard or other serious societal threat (such as threats to the democratic process), and the stakes are high. Questions about the kinds of risks deemed unacceptable must be deliberated and decided upon by the community at large through open, transparent and accountable deliberation, taking into account the EU's legal framework and obligations under the Charter of Fundamental Rights.

26.3 ***Give due consideration to the level of autonomy in AI-based decision-making*** (e.g. is it an information source only, a support function, or a fully autonomous system without human involvement) and the autonomy in learning when developing and updating policy measures for AI systems.

26.4 ***Foster a principle-based approach to regulation.*** Unnecessarily prescriptive regulation should be avoided. In contexts characterised by rapid technological change, it is often preferable to adopt a principled-based approach, as well as outcome-based policies, subject to appropriate monitoring and enforcement. The European Commission should ground its policy measures on AI in EU values, as discussed and presented in our Ethics Guidelines, and should translate our aspirational goal of Trustworthy AI into a concrete set of indicators that can be used for monitoring the convergence of the European market towards the desired policy goals.

26.5 ***Consider the adoption of a segment-specific methodology when further developing the regulatory framework for AI.*** Both the necessary measures to protect individuals against adverse effects and the market environment of AI products and services developed and deployed in the B2C, B2B and P2C contexts differ from each other and merit a tailored approach.

27. EVALUATE AND POTENTIALLY REVISE EU LAWS, STARTING WITH THE MOST RELEVANT LEGAL DOMAINS

27.1 ***Conduct a systematic mapping and evaluation of all existing EU laws that are particularly relevant to AI systems. This should be done through a Commission Inter-Service group that ensures collaboration across different DGs or the Secretariat-General to avoid "silo"-thinking.*** Three questions are to be addressed in particular: (1) To what extent are the policy and legal objectives underpinning these legislative provisions affected by AI systems and in what ways? (2) To what

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52 This can for instance be done on the basis of their impact (acceptable or unacceptable) and/or probability of occurrence (certain v uncertain).

53 This includes not only tangible risks to human health or the environment, but also includes intangible risks to fundamental rights, democracy and the rule of law, and other potential threats to the cultural and socio-technical foundations of democratic, rights-respecting, societies. For a discussion of adverse impacts associated with contemporary AI systems, see Council of Europe (2019), *Revised draft study of the implications of advanced digital technologies (including AI systems) for the concept of responsibility within a human rights framework*. Available at: https://rm.coe.int/a-study-of-the-implications-of-advanced-digital-technologies-including/168094ad40.

54 The European Commission has held that "*whether or not to invoke the Precautionary Principle is a decision exercised where scientific information is insufficient, inconclusive, or uncertain and where there are indications that the possible effects on the environment, or human, animal or plant health may be potentially dangerous and inconsistent with the chosen level of protection*". Communication from the European Commission on the Precautionary Principle, COM/2000/0001, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52000DC0001.

extent are existing frameworks for monitoring, information-gathering and enforcement of the legislative measures capable of providing meaningful and effective oversight to ensure that the policy and legal objectives are still effectively met? (3) To what extent does existing legislation operate in ways to promote and ensure the ethical principles and requirements set out in the Ethics Guidelines?

27.2 ***For civil liability[55] and accountability rules*****:** in the context of laws in areas significantly affecting individuals, consider whether for safety-critical and fundamental rights-critical applications it is necessary or desirable to introduce traceability and reporting requirements for AI applications to facilitate their auditability, ex-ante external oversight before AI systems can be deployed, systematic monitoring and oversight by competent authorities on an ongoing basis, and the obligation for meaningful human intervention and oversight when using AI decision in specific sectors (e.g. a human doctor to check a medical treatment decision). Finally, civil liability rules must be able to ensure adequate compensation in case of harm and/or rights violations (either through strict or tort liability), and may need to be complemented with mandatory insurance provisions.

27.3 ***For criminal law provisions:*** consider the need to ensure that criminal responsibility and liability can be attributed in line with the fundamental principles of criminal law.

27.4 ***For consumer protection rules*****:** consider the extent to which existing laws have the capacity to safeguard against illegal, unfair, deceptive, exploitative and manipulative practices made possible by AI applications (for instance in the context of chatbots, include misleading individuals on the objective, purpose and capacity of an AI system) and whether a mandatory consumer protection impact assessment is necessary or desirable.

27.5 ***For data protection rules:*** consider whether existing laws allow sufficient access to public data and data for legitimate research purposes whilst preserving privacy and personal data protection, the appropriate scope of intellectual property rights protection, and whether the GDPR mandated transparency and explainability offers sufficient protection in light of the limitation of its scope to the processing of personal data and the fact that automated decision-making processes can also significantly affect individuals when the system is not fully automated or based on non-personal data.

27.6 ***For non-discrimination provisions*****:** consider the extent to which laws prohibiting unlawful discrimination require the explicitation of obligations upon AI developers to verify the absence of unjust bias in AI systems' decisions, and the adequacy of enforcement mechanisms against discriminatory outcomes.

27.7 ***For cyber-security rules*****:** consider the extent to which the current cybersecurity regime provides sufficient protection against cybersecurity risks posed by AI systems.

27.8 ***For competition rules*****:** consider the volume of data or incumbency data advantages – the building block of many AI systems – in the assessment of market power for the purposes of applying rules on anti-competitive behaviour, abuse of dominance or (algorithmic) collusion, and when evaluating mergers.

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[55] It should be noted that the European Commission has set up a separate Expert Group with the task to evaluate the current legal framework for liability. More information on this Expert Group and its work is available at: http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3592.

28. CONSIDER THE NEED FOR NEW REGULATION TO ENSURE ADEQUATE PROTECTION FROM ADVERSE IMPACTS

28.1 Examine the need for new regulation to address the critical concerns listed in our Ethics Guidelines for Trustworthy AI. More generally, it should continuously be evaluated whether AI systems generate risks that are not adequately addressed by existing legislation. In particular, individuals should not be subject to unjustified personal, physical or mental tracking or identification, profiling and nudging through AI powered methods of biometric recognition such as: emotional tracking, empathic media, DNA, iris and behavioural identification, affect recognition, voice and facial recognition and the recognition of micro-expressions. Exceptional use of such technologies, such as for national security purposes, must be evidence based, necessary and proportionate, as well as respectful of fundamental rights.

28.2 Monitor and restrict the development of automated lethal weapons, considering not only actual weapons, but also cyber attack tools that can have lethal consequences if deployed. With respect to offensive LAWS[56], advocate to the Member States to actively participate in the ongoing international debate, involve internationally recognised, non-military funded scientists and academics, experts in artificial intelligence, and propose to international partners the adoption of a moratorium on the development of offensive LAWS.

28.3 Monitor the development of personalised AI systems built on children's profiles and ensure their alignment with fundamental rights, democracy and the rule of law. Consider introducing a legal age at which children receive a "clean data slate" of any public or private storage of data related to them as children.[57]

28.4 For AI systems deployed by the private sector[58] that have the potential to have a significant impact on human lives, for example by interfering with an individual's fundamental rights at any stage of the AI system's life cycle[59] and for safety-critical applications, consider the need to introduce: a mandatory obligation to conduct a trustworthy AI assessment (including a fundamental rights impact assessment which also covers for example the rights of children, the rights of individuals in relation to the state, and the rights of persons with disabilities[60]) and stakeholder consultation including consultation with relevant authorities; traceability, auditability and ex-ante oversight requirements; and an obligation to ensure appropriate by default and by design procedures to enable effective and immediate redress in case of mistakes, harms and/or other rights infringement.

29. CONSIDER WHETHER EXISTING INSTITUTIONAL STRUCTURES, COMPETENCES AND CAPACITIES NEED REVISION TO ENSURE PROPORTIONATE AND EFFECTIVE PROTECTION

We recommend a systematic evaluation of the extent to which existing institutional structures, competences, capacities, resources, investigation and enforcement powers arising under existing legislation are capable of adequately ensuring meaningful and effective information-gathering, monitoring and enforcement of legal standards in ways that provide proportionate and effective protection. In this regard, consideration may be warranted for the necessity or desirability of the points listed here below.

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56 These are military robots which, without any human intervention, can select, engage, attack and hit civilian and military targets.

57 This does not exclude the possibility for appropriate exceptions that are necessary in a democratic society and in full compliance with fundamental rights.

58 For AI systems in the public sector, please refer to Recommendation 12.1.

59 When referring to AI systems with a high or significant risk for individuals, reference can be made to Art 35 of the GDPR, which could serve as a model for a definition.

60 With due regard to the UN Convention on the Rights of persons with disabilities.

29.1 ***Ensure the consolidation of EU institutions' "policy cycle" approach by more systematic monitoring and periodic ex-post evaluation of regulatory measures, and by enhancing stakeholder consultations.*** The stakeholder consultation system of the Commission should be adapted to the AI age, and important ethical questions should be approached with the help of a wide consultation of civil society. In this context, the European AI Alliance could be further developed and relied on as an important channel.

29.2 ***Consider agile policy-making solutions such as the creation of regulatory sandboxes to help stimulating innovation without creating unacceptable risks.*** The creation of regulatory sandboxes should involve multiple public and private stakeholders (including NGOs) to support innovators and allow for high pace viability assessments for new innovations and business models, without hampering the public interest and the protection of individuals. The limitations of sandboxes should be assessed, and the sandbox' transparency and accountability must be ensured, including the availability of avenues of redress in case of harm or adverse impact. Sandboxes can also help developing impact assessment capabilities, which facilitates the fundamental rights impact assessment of experimental AI implementations.

29.3 ***Institutionalise a dialogue on AI policy with affected stakeholders to define red lines and discuss AI applications that may risk generating unacceptable harms,*** including applications that should be prohibited and/or tightly regulated or in specific situations where the risk for people's rights and freedoms would be too high and the impact of this technology would be detrimental to individuals or society as a whole. This could for instance be done through the European AI Alliance.

29.4 ***Develop auditing mechanisms for AI systems.*** This should allow public enforcement authorities as well as independent third party auditors to identify potentially illegal outcomes or harmful consequences generated by AI systems, such as unfair bias or discrimination.

29.5 ***Ensure that the use of AI systems that entail interaction with end users is by default accompanied by procedures to support users in accessing effective redress in case of infringement of their rights under applicable laws.*** These procedures should be accompanied by simple explanations and a user-friendly procedure, and should entail interaction with a human interlocutor whenever possible and chosen by the user. Access to justice and effective redress are key elements of building consumer trust and thus are an important part of Trustworthy AI.

29.6 ***Foster the availability of redress-by-design mechanisms.*** This entails establishing – from the design phase – mechanisms to ensure alternative systems and procedures with an adequate level of human oversight (human in the loop, on the loop or in command approach) to be able to effectively detect, audit, and rectify incorrect decisions taken by a "perfectly" functioning system, for those situations where the AI system's decisions significantly affects individuals.

29.7 ***In addition, we urge policy-makers to refrain from establishing legal personality for AI systems or robots.*** We believe this to be fundamentally inconsistent with the principle of human agency, accountability and responsibility, and to pose a significant moral hazard.

30. ESTABLISH GOVERNANCE MECHANISMS FOR A SINGLE MARKET FOR TRUSTWORTHY AI IN EUROPE

Achieving the Single European Market is crucial both to ensure a level playing field in terms of protective regulation, as well as to enable competitiveness of European companies both in Europe and globally. The New Legislative Framework adopted in 2008 can be an enabling framework to accelerate this. Subject to the provisions of subsidiarity and proportionality, we propose that new regulatory frameworks related to AI systems, including all digital aspects associated therewith, should be developed at European level.

30.1 Harmonise regulation – including its implementation and enforcement mechanisms – across the EU and foster cooperation between Member States regarding regulatory frameworks relevant to AI throughout Europe. In particular, complete and harmonise the EU data regulatory framework. Harmonisation should however not preclude existing higher standards of protection at national level with regards to individuals, for instance regarding individuals' health and safety and consumer protection.

30.2 Cumulative regulatory interventions at the national level should be avoided, unless strictly satisfying the principles of subsidiarity, necessity and proportionality. Fragmentation of rules at Member State level should be avoided and the creation of a true European Single Market for Trustworthy AI systems and services should be prioritised.[61] The relevant EU law mapping exercise proposed under Recommendation 27.1 should also identify areas where harmonisation of rules may be appropriate to foster this goal.

30.3 Establish a comprehensive strategy for Member State cooperation for the enforcement of regulation relevant to AI through enforcement authorities such as data protection, consumer and competition authorities, ensuring that they cooperate across sectors systematically and apply EU regulations in a consistent manner throughout different Member States and that they have adequate and equally effective resources and enforcement tools in place.

30.4 Foster the harmonisation of Trustworthy AI standards by contributing to the Guidelines' piloting process and ensuring an appropriate follow-up. With the aim to establish a European-wide framework for trustworthy AI, the Ethics Guidelines put forward a practical assessment list. To better understand how this guidance can be implemented in different applications, sectors and Member States, a piloting process was established. Member States should encourage stakeholders to participate in this process and ensure funding to enable civil society organisations to participate. European Institutions and (national) public organisations should participate themselves in case they develop, deploy or use AI systems. Moreover, the Commission should ensure an appropriate follow-up process to the revised assessment list in early 2020.

30.5 The European Union should consider the setting up an institutional structure for Trustworthy AI to fill an existing governance gap. It would be tasked with the following missions:

- Contribute to developing the EU's framework and policy for Trustworthy AI, ensuring that AI is lawful, ethical and robust, by advising EU institutions and supporting them in the implementation of such framework;
- Provide guidance to stakeholders on how their AI applications can comply with the applicable law and the principles and requirements for Trustworthy AI;
- Assist the public and private sector in the application of a risk-based approach. This includes providing opinions for the assessment of the intensity, probability and unacceptability of AI-created risks;
- Oversee politically defined system-wide targets for AI applications that can significantly impact individuals and society, considering systemic effects both in terms of benefits and risks;
- Help standard setting organisations define target outcomes for Trustworthy AI, in particular in the context of public-private cooperation on standards;

[61] At the same time, we acknowledge that there may be specific sectors where additional regulatory requirements apply compared to the future horizontal policy framework for AI in the EU: sectors such as banking, insurance and healthcare are already exposed to significant regulatory requirements that are likely to overlap with the emerging policy framework for AI. In these sectors, as well as any other sector that will features such overlaps, it is essential that the European Commission performs regular fitness checks to ensure that legislation is proportionate, clearly designed and effectively implements.

- Promote cooperation amongst Member States for the implementation of Trustworthy AI;
- Host and update a repository of best practices that are deemed compliant with applicable law and the Trustworthy AI principles and requirements;
- Contribute to preparing for socio-economic changes brought about by AI, for example through awareness campaigns and training measures for public institutions.

30.6 Develop guidance for stakeholders on how to ensure compliance with Trustworthy AI's first component, lawful AI, for each of the seven requirements. In the Guidelines, guidance is provided on how to ensure the implementation of ethical and robust AI for each of the seven requirements. However, as those requirements are also already captured by a number of legal obligations, and as legal uncertainty exists regarding the extent to which such legal obligations are already in place, a guidance document on this first component would be welcomed.

30.7 Consider a range of certification mechanisms for AI systems, and assess the necessity of technical standards and other standardisation measures.[62] The development of co-regulation mechanisms for the certification of AI systems at EU level could counter fragmentation of standards, but could also help provide the means to assess the quality of an AI solution after deployment and possibly to decide which solution is best. Feedback received through the piloting phase of the Ethics Guidelines could help assess the necessity and shape of any such mechanism. As concerns standardisation, Europe should develop a clear strategy in terms of key standardisation fora and adequate resources. A European vision is needed on the main components of Trustworthy AI that may necessitate standards. Finally, it should be ensured that AI systems comply with mandatory sectoral certification requirements that already exist today.[63]

H. Raising Funding and Investment

The availability of capital is essential for rapid market expansion, and Europe has a challenging position with a two- to five-fold investment gap compared with other world regions. Europe currently attracts only ~11% of global VC funding, with ~50% going to US and the rest mostly to China.[64] An assessment of the economic activity growth due to AI until 2030 shows that the value at stake for Europe is significant: if no actions are taken, the EU28 will suffer a deterioration of its innovation capital, which would result in a loss of €400 billion in cumulative added value to GDP by 2030.[65] On the other hand, if Europe develops and diffuses AI according to its current assets and digital position relative to the rest of the world, it could add €2.7 trillion, or 19%, to output by 2030.[66] Investments in companies supported by the European Investment Fund across the EU shows a stabilisation of around €90 million per year over 2017-2018 in the EU27 (€128 million for the EU28) for about 50 AI-related deals (70 for the EU28),[67] which is clearly insufficient for the EU to be a major actor in volume of investments. The EU therefore urgently needs an intensification of investments.

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62 Consideration should be given to the failure of certification systems to safeguard against the implementation of 'cheat devices' in diesel vehicles by a leading car manufacturer on a massive scale, and lessons learned from that experience.

63 See in this regard also the New Legislative Framework for instance, on which more information can be found at: https://ec.europa.eu/growth/single-market/goods/new-legislative-framework_en.

64 See KPMG, Venture Pulse, 2018, https://assets.kpmg/content/dam/kpmg/xx/pdf/2019/01/kpmg-venture-pulse-q4-2018.pdf.

65 See McKinsey Global Institute, Notes from the AI frontier, Tackling Europe's Gap in Digital and AI, February 2019.

66 Ibidem.

67 Data includes all deals notified to the European Investment Fund up until 31/1/2019 and might not yet reflect all 2018, Q4 deals.

The private investment gap in AI in Europe, which "totalled around € 2.4-3.2 billion in 2016, compared with € 6.5-9.7 billion in Asia and € 12.1-18.6 billion in North America",[68] was duly acknowledged in the Commission's AI strategy of April 2018, which sets an ambitious objective: increase investment and reaching a total (public and private sectors combined) of at least €20 billion per year in the course of the next decade. To achieve this, the Coordinated Plan on AI prepared by the Commission and Member States set out a number of investment actions. Furthermore, the Commission proposed a number of financing initiatives in its 7-year Multiannual Financial Framework (MFF), for instance in terms of research areas (such as explainable AI, unsupervised machine learning or energy and data efficiency) or infrastructures (upgrading the pan-European network of AI excellence centres, creating additional Digital Innovation Hubs, and establishing world-leading testing and experimentation facilities). The implementation of these actions requires the swift adoption by Member States of the MFF and its instruments. Amongst those instruments, the Digital Europe programme (of which €2.5 billion is allocated to the uptake of AI) and the Horizon Europe programme (of which €700 million is allocated to research in AI and other digital technologies) are important steps. We address in this section the need to steer public funding towards the recommendations set out in the sections above, as we believe this can help leveraging private funding, and create a more attractive investment environment for trustworthy AI in Europe.

31. ENSURE ADEQUATE FUNDING FOR THE RECOMMENDATIONS PUT FORWARD IN THIS DOCUMENT

Throughout this document, various recommendations necessitate dedicated funding mechanisms to be put in place by the European Commission together with Member States in order to enable their implementation. We limit ourselves here to the most significant ones:

31.1 Transitions taking place on the job market and the workplace require a European transition fund to help managing this in a socially responsible way (Recommendation 3.6). Moreover, the re- and up-skilling of the workforce in Europe, and the securing of a work-life-train balance, will require significant public funding, particularly at national level – which will need to be supported by even more significant levels of private funding.

31.2 The earmarking of substantial funding in the InvestEU programme for AI (Recommendations 6.1 and 7.1) can help organisations to tackle the digital transformation. While structurally this agency could be part of the European Investment Bank, its methods and instruments need to be adapted to the specific needs of the AI ecosystem.

31.3 The proposed Multi-Stakeholder Alliances that will enable AI ecosystems on a sectoral basis (Recommendation 8.2) will necessitate the availability of public funds that can help back solutions proposed by the relevant stakeholders. Those Alliances can not only help in analysing the concrete investment needs for the sector in question from different angles, but can also stimulate funding commitments from industry through a collaborative environment of trust that such ecosystem can create.

31.4 Within public procurement processes, both at EU and national level, a substantive amount should be allocated to innovation-driven solutions (Recommendation 11.1). This can serve as an instrument to fund innovative AI-based solutions in Europe.

31.5 Dedicated, significant and long-term research funding is needed for fundamental and purpose-driven research on AI to maintain competitiveness of European companies and address relevant societal challenges (Recommendation 14.1). In particular, funding should be made available to

[68] See Euralarm report, available at: https://www.euralarm.org/download/87_e78189598ff22b4a957c46350831c66c.

collaborative research, which can help creating projects of a critical mass on targeted topics, rather than focusing solely on individual projects without global coherence. This can help bringing research teams together to work towards common objectives. Currently, no instrument is available at European level that would support this type of high-level basic research, which could nevertheless play an anchoring role for researchers to stay in Europe, and attract the best ones from abroad.

31.6 A structural and investment fund for European data infrastructure is proposed in order to support ecosystems to coordinate data sharing and access (Recommendation 18.1). Opening publicly funded data sources, and redirecting funding flows to foster collaboration between public and private sector is critical to enhance Europe's competitiveness.

31.7 The establishment of an institutional structure at EU level for Trustworthy AI will likewise require resources to be made available (Recommendation 30.5). Such resources should come both from the European Union's budget and from Member States, as close cooperation with relevant Member State authorities will be necessary.

32. ADDRESS THE INVESTMENT CHALLENGES OF THE MARKET

The forecast of the AI worldwide market value shows a fast growth, with AI reaching $118 billion by 2025 from $9.5 billion in 2018.[69] AI is a family of deep technologies at a stage of development where volumes of investments make a difference in terms of innovation speed and market share, notably in areas that will underpin the future digital systems and services. With the digital economy being characterised by a "winner takes all"-logic and diminishing returns for late entrants, it is essential for European actors to invest as first movers so as to have the possibility to capture large market shares. Slow movers will have to catch up with established market players, which is expected to be difficult, especially as market growth is estimated to decline after having reached a high in 2021.[70] The market pull for European AI start-ups is rather weak but needs to be anticipated to ensure that the engines of the European economy embrace the shift to AI, bringing benefits to the European economy.[71]

32.1 Introduce EU level thematic actions to build synergies between national initiatives, to encourage new public initiatives and to mobilise and leverage private investments. Financing by EU Institutions and Member States is crucial for creating bigger funding pools and leveraging private investments to AI-focused start-ups and SMEs – and for accelerating the digital transformation of Europe. Member States need to seek such co-investments at European level (e.g. through their National Promotional Banks) to crowd-in additional investments by the private sector. Such co-investments also have to address the large investments targeting company growth, beyond the priority actions of Member States already identified in the Coordinated Plan for AI.

32.2 Encourage Member States to create and expand the testing and experimentation facilities proposed in the EU initiative of the Digital Europe programme, and raise awareness by SMEs, notably from traditional sectors of the economy, to adopt and digitally transform. A dense network of Digital Innovation Hubs should be actively diffusing digital and AI-enabled technologies.

32.3 Ensure financing avenues for larger market deals that can help established companies grow and scale up in the digital economy ("scale without mass" until generating revenues). Although existing European and national instruments primarily aim at the market gap in equity finance for the early-

[69] Tractica, Artificial Intelligence Market Forecasts, https://www.tractica.com/research/artificial-intelligence-market-forecasts, 19Q1.

[70] Ibidem.

[71] Roland Berger, Artificial Intelligence – A strategy for European start-ups, 2018.

and growth stage of start-ups and SMEs (seed-series A), it is equally critical to address the market gaps of bigger deals, in the order of €100 million and more (series C and D).[72]

32.4 ***Set up a European Coalition of AI Investors (ECAI),*** which gathers companies in Europe that pledge to allocate funding for and investment in the European AI ecosystem.

33. ENABLE AN OPEN AND LUCRATIVE CLIMATE OF INVESTMENT THAT REWARDS TRUSTWORTHY AI

33.1 ***Encourage the Commission to work with European financial institutions, such as the European Investment Bank, to develop investment guidelines that take into account the Ethics Guidelines,*** leading to sustainable business developments. This could take the form of a criterion in the social proofing of future financial investments such as InvestEU. The appraisal of the Ethics Guidelines by all stakeholders, and notably industry and other international organisations, indicates how technologies with human-centric values are critical to ensuring societal acceptance.

33.2 ***Ensure the EU remains an open economy, and a lucrative place for innovators and investors*****.** Europe's lucrative investment environment is the sum of a number of enabling elements – from its labour and immigration regime to the legal certainty created through its regulation – that as an aggregate can provide the necessary level of attraction to bring in investors. Achieving the AI investment target set by the EU will require an increase in the EU's investment attractiveness. In the current context of global trade uncertainties and protectionist actions by other world regions, it is essential that the EU remains a champion of free trade and investment in the world, while taking decisive action to counter unfair practices by third countries.[73]

[72] KPMG, Venture Pulse (2018), https://assets.kpmg/content/dam/kpmg/xx/pdf/2019/01/kpmg-venture-pulse-q4-2018.pdf.

[73] EPSC, "EU Industrial Policy After Siemens-Alstom, Finding a New Balance Between Openness and Protection", March 2019, https://ec.europa.eu/epsc/sites/epsc/files/epsc_industrial-policy.pdf.

CONCLUSION: KEY TAKEAWAYS

Europe has set its overarching ambition on a human-centric approach to Artificial Intelligence. In our first deliverable, this concept was captured in the notion of Trustworthy AI, which we characterised in terms of three components – being lawful, ethical and robust – and in line with the core tenets of the European Union: fundamental rights, democracy and the rule of law. Our Ethics Guidelines for Trustworthy AI hence constituted a crucial first step in delineating the type of AI that we want and do not want for Europe.

While such delineation is necessary, it is however not enough to ensure that Europe can also materialise the beneficial impact that AI can generate. Taking the next step, this document therefore presents a set of policy and investment recommendations on how Trustworthy AI can actually be developed, deployed, fostered and scaled in Europe, all the while maximising its benefits whilst minimising and preventing its risks.

We recall that Trustworthy AI is not an end itself, but can be a means to enhance individual and societal well-being. This requires sustainability, in order to safeguard our societal and natural environment for generations to come. It requires growth and competitiveness, so as to grow the pie, secure employment opportunities and generate beneficial progress. And it requires inclusion, to allow everyone to benefit therefrom. Technology is a crucial driver of innovation and productivity, and AI is one of the most transformative technologies of our time. We believe that Trustworthy AI can help achieving sustainability, growth and competitiveness, and inclusion – thus contributing to individual and societal well-being.

For this purpose, we formulated 33 concrete recommendations addressed to the European Institutions and Member States. These focus on four main areas where we believe Trustworthy AI can help achieving a beneficial impact, starting with humans and society at large, and continuing then to focus on the private sector, the public sector and Europe's research and academia. At the same time, we looked into the main enablers needed to facilitate those impacts, evolving around the availability of data and infrastructure, skills and education, appropriate governance and regulation, as well as funding and investment.

We list here below the main takeaways from our report:

1. **Empower and protect humans and society**

   Using Trustworthy AI to enhance our well-being implies important prerequisites, in particular securing individual and societal empowerment and protection. First, individuals need to be aware of and understand the capabilities, limitations and impacts of AI. Second, they must have the necessary education and skills to use the technology, to ensure that they can truly benefit therefrom as well as being prepared for a transformed working environment where AI systems will become ever more prevalent. And third, they need adequate safeguards from any adverse impact that AI might bring.

2. **Take up a tailored approach to the AI landscape**

   When positioning Europe in the AI landscape, policy-makers must adopt a tailored approach. They should consider the "big picture", by looking at AI's overall impact on – and potential for – society, while simultaneously understanding the sensitivities of AI solutions in B2C, B2B and P2C contexts, both as digital products and services only, and as digital solutions embedded in physical systems. The underlying logic of each of those segments across different sectors should be analysed and harnessed, both in terms of impacts to be made and the enablers needed, including governance measures.

3. **Secure a Single European Market for Trustworthy AI**

   A major achievement in Europe over the last few decades has been the creation of the Single Market, which – as we move into the new economic and technological wave that is created by AI – must also

focus on a Single European Market for AI. This is a complex and multifaceted undertaking which includes the avoidance of market fragmentation, for instance through the harmonisation of legislation where appropriate, while at the same time maintaining a high level of protection of individuals' rights and freedoms across all Member States. Establishing a level playing field for Trustworthy AI across Europe can benefit individuals and organisations by removing barriers to procure lawful, ethical and robust AI-enabled goods and services, while also ensuring a competitive position on the global market through economies of scale enabled by large integrated markets.

4. **Enable AI ecosystems through Sectoral Multi-Stakeholder Alliances**

   Implementing the recommendations put forward in this document necessitates stakeholder cooperation. It is only by joining forces and bringing all relevant actors – from civil society, industry, the public sector and research and academia – around the table, that we can make a difference. Together, these can help giving shape to vibrant AI ecosystems on a sectoral basis, which can enable a more granular and much-needed analysis of the specific needs, challenges and opportunities to seize the benefits of AI within those respective sectors. We propose to start laying the groundwork for this in the second half of 2019, building on the current report.

5. **Foster the European data economy**

   Europe must foster and invest in a European data economy. The data-driven economy is a cornerstone for the EU's future success in the global market. A whole set of policy actions are needed for European organisations to generate societal benefits and succeeding in global competition, including provisions for data access, data sharing, use of data, re-use of data and data interoperability, all the while ensuring high privacy and data protection standards for individuals. This also requires putting in place the necessary (physical) infrastructures to enable the other building blocks needed to develop and deploy Trustworthy AI in Europe.

6. **Exploit the multi-faceted role of the public sector**

   The public sector plays a vital role in steering Europe's future. It is uniquely placed to deliver and promote human-centric and Trustworthy AI services, leading by example, while ensuring a strong protection of fundamental rights. Public procurement-based innovation provides a great opportunity not only to incentivise the development of novel AI solutions that can optimise public services, but also to foster Trustworthy AI solutions amongst European companies of all sizes, and to create beneficial solutions in their own right for application elsewhere. Finally, the public sector is in a crucial position to bring all stakeholders together and maximise joint efforts towards our overarching aims.

7. **Strengthen and unite Europe's research capabilities**

   Europe must focus the power of its distributed research landscape to establish and demonstrate its intellectual and commercial leadership in AI. It should strengthen and create additional Centres of Excellence in AI, and foster collaboration with other stakeholders, including small and large companies, the public sector, as well as society at large. An ambitious research roadmap for AI should be developed, which includes grand challenges of global relevance, respects and fosters Trustworthy AI, and substantially impacts human-centric application domains. It should focus on Europe's strengths, opportunities and areas of strategic importance, and be constantly updated based on new developments and stakeholder consultation. Research funding should be increased and streamlined to build a unified AI capacity for Europe, which will ensure world-class research capabilities that can also help develop, retain and acquire AI talent.

8. **Nurture education to the Fourth Power**

   A sufficiently deep and wide skills base is needed to support our Trustworthy AI ambitions. This starts with raising awareness and providing education on AI's capabilities, challenges and limitations, as well as teaching appropriate skills to deal with this, whilst ensuring an inter- and multidisciplinary perspective. Primary (1), secondary (2) and tertiary (3) education models need to take this into consideration, and continuous learning (4) – including on-job learning – must secure the re- and up-skilling of individuals for the new digital era in Europe, establishing a work-life-train balance.

9. **Adopt a risk-based governance approach to AI and an ensure an appropriate regulatory framework**

   Ensuring Trustworthy AI requires an appropriate governance and regulatory framework. We advocate a risk-based approach that is focused on proportionate yet effective action to safeguard AI that is lawful, ethical and robust, and fully aligned with fundamental rights. A comprehensive mapping of relevant EU laws should be undertaken so as to assess the extent to which these laws are still fit for purpose in an AI-driven world. In addition, new legal measures and governance mechanisms may need to be put in place to ensure adequate protection from adverse impacts as well as enabling proper enforcement and oversight, without stifling beneficial innovation.

10. **Stimulate an open and lucrative investment environment**

    Europe must harness its lucrative investment environment. The new Horizon Europe and Digital Europe programmes set firm steps towards enhanced European investment levels in AI, yet much more needs to be done on the public side, and real successes can only be achieved through significant private sector support. We believe that sectoral multi-stakeholder alliances that foster trust across policy-makers, industry and academia as well as society, can help securing those investments, as well as steering them towards Trustworthy AI.

11. **Embrace a holistic way of working, combing a 10-year vision with a rolling action plan**

    To achieve these goals, Europe needs a holistic strategy with a long-term vision that can capture the opportunities and challenges of AI for the next 10 years. At the same time, a framework is needed that allows continuous monitoring of the landscape and adapting impactful actions on a short-term rolling basis. In this regard, the yearly update of the Commission's and Member States' Coordinated plan for AI is a welcome development and should be secured. In a competition amongst different economic entities, the single most important element is the capability to apply and learn fast and consistently over a long period of time. This report on Policy and Investment Recommendations, together with earlier published Ethical Guidelines on Trustworthy AI, is a first step to establish the foundation for this durable strategy. However, a long-term follow-up scheme for their implementation is crucial if we truly wish to move the needle in Europe.

As concrete next steps to pave the road for this new way of working, in the second half of 2019 we will (1) run a piloting phase of the Ethics Guidelines for Trustworthy AI to enable their improvement and secure their (sectoral) relevance, and we propose to (2) instigate a limited number of sectorial AI ecosystem analyses. Building on this report's cross-sectoral recommendations, we believe it is now necessary to learn which and impactful actions should be undertaken for various strategic sectors, covering all the areas of impact and the enablers mentioned in this report.

A major opportunity is knocking on Europe's door. That opportunity is AI-enabled. Europe's readiness to respond to this opportunity must be ensured, which requires action now. We wish to convey a sense of urgency to policy-makers both at European and national level to gain momentum in applying Trustworthy AI for the benefit of individuals and societies in Europe.

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