Strategic Research, Innovation and Deployment Agenda for an AI PPP

A focal point for collaboration on Artificial Intelligence, Data and Robotics

Second Consultation Release
September 2019

A joint initiative by

BDV BIG DATA VALUE ASSOCIATION

eu ROBOTICS

Artificial Intelligence – a real business driver for Europe?

Artificial Intelligence (AI) is on everyone's lips. Nearly every country has launched an AI action plan and undertaken activities for the adoption of AI, from research through to deployment. Almost everyone now realises that AI offers high business growth potential – a fact underscored by official forecasts.

In his recent book "AI Superpowers" Kai-Fu Lee, former head of Google in China, writes in the conclusion: "As both the creative and disruptive force of AI is felt across the world, we need to look to each other for support and inspiration."

That is why we in Europe should ask ourselves how we will handle this technology. What is the **European approach**? How can we build on **European strengths** and achieve **sustainable effects** for the European economy and for European companies worldwide?

One aspect is perfectly clear: AI will only be successful for us if there is a specific market for its solutions. And there will only be such a market if we create **AI applications that benefit customers and society**. Only then will customers be willing to pay for the benefits provided by AI, and only then will society embrace AI.

This is something we can achieve by following – and fulfilling – the recommendations made by the HLEG to cultivate trust in AI and make it easily explainable, the latter being essential for the former.

Furthermore, AI-related activities should be **measurable** to ensure that AI performance is related to the objectives pursed by businesses and customers.

Our mission must therefore be to increase and **demonstrate the value of AI to customers and society in Europe** and around the world. Europe, with its industry knowledge in specialized fields, has an important competitive advantage that must now be exploited in the market.

Let's look at three concrete examples:

- In industries, our AI technologies can be used to further enhance the optimization of underlying value-added processes and thereby raise the effectiveness and efficiency of processes to a new stage of organization and management.
- In healthcare, our AI applications can be used to analyze information about rare diseases – collected by patients all over the world – and to leverage new insights for the benefit of patients to a degree that would have been unimaginable in the past.
- And in mobility, we are already using AI to significantly reduce emissions by optimizing supply and demand without sacrificing the value proposition for individual customers.

On the basis of these and many other examples, we intend to systematically hone our **European value proposition for AI**. These "best practice" examples enable us to provide further business scenarios that offer real added value.

But how can we achieve this? To start, we must adopt a holistic view that takes

multiple aspects into account – from the functionality and real-world applications of the technology itself, to its business and societal implications. In doing so, we will be better positioned to more cogently articulate and demonstrate the tangible value of AI – for not only enhancing the revenue-generating potential for companies' business models, but also enriching our society as a whole. There are already many great examples, but we must continue to elaborate further.

From a functionality perspective, we have scoped a **European AI Framework** that builds on European fundamental rights and values, an AI innovation ecosystem and includes **AI technology enablers** that cover multiple verticals.

The building blocks that result from these technology enablers must then be integrated into concrete **technological systems** as they are used in different verticals. From manufacturing to healthcare and mobility, most industries use systems delivered by different vendors, but by integrating these technological building blocks, we can standardise communication between these various systems.

Achieving this in and for Europe will require **open and inclusive collaboration** between **different stakeholders** who each bring their own, unique specialised technological expertise to the table – which can range from embedded systems, communication and security, to computing and domain applications, among others. Fortunately, there are currently many major initiatives in Europe that strive to deepen this kind of **horizontal collaboration**, which will be increasingly necessary in the years ahead.

Crucially, the research we conduct must remain **a strong, driving force well into the future**. Only on the basis of such research we can prepare ourselves for the future. Research is the backbone of business applications. And that is why we are pleased to have established such close collaboration with major research initiatives!

Many thanks to all who have contributed to this next "Strategic Research, Innovation and Deployment Agenda" on our **common road** to a **EUROPEAN AI PPP**!

Dr. Bernd Liepert
euRobotics President

Thomas Hahn
BDVA President

eu ROBOTICS

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Artificial intelligence will transform many if not all branches of economic activity, and Europe must get its act together to remain globally competitive. At Philips, we are convinced that AI will in particular be one of the key enablers of the digital transformation of healthcare – which is urgently needed in order to be able to contain costs and assure adequate access to care for all. This in the face of a rise of chronic conditions, an ageing population, and a rapidly increasing shortage of qualified healthcare professionals. The application of AI will be key to be able to turn personal health and contextual data from ubiquitous connected medical devices at the hospital and in the home into actionable insights – and then into the right actions. It is urgently needed to boost the adoption of technologies like advanced machine learning, natural language processing, chat bots, semantic reasoning, computer vision, and the patient digital twin to healthcare systems. Europe must be at the forefront of developments in these fields – closely linked to relevant domain knowledge like biomedical sciences, medical imaging, precision diagnosis, monitoring, image guided minimally invasive therapy, clinical informatics, and population health management. To avoid fragmentation of efforts, and to be able to develop scalable solutions based on the responsible application of AI to healthcare across Europe, the establishment of a large public private partnership in Europe will be of crucial importance for the EU economy and the health and wellbeing of its people.

Dr. Henk van Houten
Chief Technology Officer, Philips

Artificial Intelligence (AI) is a powerful technology, getting more capable every year. The challenge is for industry to harness that power. The AI PPP will help achieve that by bringing together expertise in algorithms, sensors and robotics, and addressing the realities of regulation and the need to build partnerships. The AI PPP is an exciting development for the mobilisation of AI in industry.

Professor Andrew Blake
Former Laboratory Director of Microsoft Research Cambridge and former Director of Alan Turing Institute and member of ELLIS

The European approach to artificial intelligence should be based on European values. Europe can become a global leader in ethical, inclusive, privacy protecting artificial intelligence. The AI PPP is meant to create a vibrant AI eco-system that all Europeans can benefit from. It is especially important for Europe to ensure that AI is multilingual, that it understands and speaks all the languages that Europeans speak, and that it can extract knowledge out of the vast amounts of multilingual data in written and spoken forms. Small and big enterprises and language communities should be supported with tools, data, know-how and, the skills to fully embrace the potential of AI.

Dr. Andrejs Vasiļjevs
Executive Chairman, Tilde

Artificial intelligence will shift the balance of power in the shortest possible time. Here we have to see how we can assert and expand our position very quickly. Europe can and must be the pacemaker(s) for Industrial AI – where in Europe the domain knowledge is available and we have a powerful network between SMEs, big companies, research institutes and government. We need from industrial perspective fast-track programs to exploit the opportunities offered by applications of artificial intelligence for industrial and societal benefit in alignment with our European ethical principles! Therefore I very much appreciate and support the establishment of a European Public-Private Partnership on AI as a central hub to collaborate with other initiatives especially inside Europe and with all the member states … because we have one common goal: we have to boost Artificial Intelligence in Europe!

Dr. Roland Busch

Chief Operating Officer, Chief Technology Officer and member of the Managing Board of Siemens AG

Artificial Intelligence is a major strategic priority for Europe. An AI Public-Private Partnership would provide an important mechanism for bringing key stakeholders from the research and industry communities together. The European Artificial Intelligence Association was established in 1982 and is one of the oldest and largest AI associations in the world. We very much welcome an opportunity to collaborate with euRobotics and the BDVA in bringing many key capabilities within the European eco-system together to address the opportunities and challenges presented by AI.

Professor Barry O'Sullivan

President of the European AI Association

'It was the best of times, it was the worst of times'. We have entered an era of unprecedented characteristics that can prepare the path for a truly informed and sustainable development of our societies in a changing and challenging environment. The characteristics of today are the exponentially growing amount of geospatial data and the remarkable technological progress. Artificial intelligence is the only viable way for a timely extraction of added value information from the plethora of data sources becoming available and that can provide an understanding of our past and the outline of our future environment. As Europe is the leader of the biggest Earth Observation Program ever – the Copernicus program - it only strengthens the idea that Europe must be a lighthouse for Artificial Intelligence developments for the Earth Observation domain. Thus, I strongly support the establishment of a European Public-Private Partnership on AI, seeing it as a requisite to set the framework for a 'best of times'.

Dr. Florin Serban

CEO Terrasigna

__Artificial intelligence__ (AI) is a core driver of innovation, productivity and economic growth. It enables the __"Intelligent Enterprise"__ through human-machine collaboration, allowing humans to focus on higher-value work. Europe has largely contributed to the rise and upswing of AI and should keep a central role in shaping the technology's future. Broad and fast adoption of AI and the support for digital technologies by SMEs will be crucial for future European competitiveness. The public sector could become a role model for AI deployment, demonstrating that it yields tangible benefits for citizens. Europe should establish large-scale AI research and innovation clusters that are on eye-level with those in the United States and China. At the same time, AI developments need to respect European values and legal standards. This will help to address critical societal challenges and support broad social acceptance on which the success of AI in Europe depends. A European vision for human-centric AI that aims at European prosperity will be an important step in this direction. With our vision of the Intelligent Enterprise, and as a market leader in enterprise software applications, SAP supports the __European AI Public-Private Partnership__.

Juergen Mueller

Chief Technology Officer and Executive Board Member at SAP SE

CLAIRE, the European Confederation of Laboratories for Artificial Intelligence Research in Europe, is an initiative by the European AI community that seeks to strengthen European excellence in AI research and innovation. CLAIRE supports the establishment of a cPPP with the objective of increasing the rate of developing, deploying and adopting advanced technologies from the broad field of Artificial Intelligence across European industries. A PPP that seeks to increase value-creating collaboration between advanced research, universities and industry is of great importance for the development of the AI- and AI-based industry in Europe.

Professor Morten Irgens

CLAIRE , Vice Rector, Oslo Metropolitan University

Robotics and Artificial Intelligence are key enablers for offering solutions to many of our societal challenges, from demographic changes to sustainable production and healthy living. KUKA supports the foundation of a public-private partnership in AI to drive and accelerate innovation in robot-based automation across all market domains by setting clear impact-driven objectives and establishing a vivid ecosystem of researchers, enterprises and investors to achieve these objectives.

Peter Mohnen

CEO KUKA AG

One of the key issues for the future is leveraging IoT data and enabling cross-sectoral "data marketplaces", providing true interoperability, lowering regulation barriers, etc. to unlock the full potential of innovation IoT-based applications. Advancing in the convergence of IoT with other enabling technologies such as next-generation connectivity, AI, edge computing, is the key to sustain and extend European leadership in the digital innovation space. Our collaboration and support to this SRIDA document is one of the important steps in proofing the concept and ensuring it is implemented in Europe.

Natalie Samovich

AIOTI Steering Board Chairwoman and WG Smart Energy Chairwoman

Today the power of big data leads services, products and processes to a higher level of "intelligence", towards a new generation of intelligent solutions designed to improve the quality of our time and regenerate energies by identifying and anticipating needs, providing personalized services, foreseeing phenomena and optimizing the resources available ... all this strictly in line with trustworthy and ethical principles. Private industrial and research investments are already in place. In this context, a European Public-Private Partnership on AI is of extreme value to guarantee the proper alignment of forces that over the next few years will massively bring intelligent systems in everyday life. Europe cannot miss the possibility to be disruptive in the development and adoption of leading Artificial Intelligence solutions ... to be adopted inside and outside Europe.

Orazio Viele

CTO Engineering Ingegneria Informatica S.p.A.

AI for Industry is still open and Europe has a realistic chance to shape its future!
AI for Industry uses Industrial Data which is generated by Industrial processes.
AI for Industry is the natural next step after the adoption of Big Data and Analytics by Industry.
AI for Industry needs to show measurable results which can be endorsed by businesses.
AI for Industry requires scarce industrial resources to build the model and to label the results.

Therefore we very much appreciate the European activities towards AI Public Private Partnership which will give us the central access point for AI in strong and inclusive collaboration with all AI activities in Europe!

Hubert Tardieu

CEO Advisor, Atos SE

Europe has the fundamentals to be a leader within artificial intelligence, data analytics and robotics in a way the benefit both industry and society. However, the global competition is fierce, and leadership requires that the public and private side jointly invest massively and wisely into the new opportunities to create business opportunities, develop digital skills and to keep and attract new talent. European Public-Private Partnership on AI (AI-PPP) would be a central instrument to pool together the resources needed and to network big companies, SMEs, start-ups with research institutes, universities and government

Dr. Tua Huomo

Executive Vice President, Knowledge Intensive Products and Services, VTT Technical Research Centre of Finland Ltd.

Artificial Intelligence is key to the development of the economy and society. Its transversal nature favors its incorporation to all sectors and requires new ecosystems of public-private partnerships and new agile instruments that promote the transfer of knowledge from the university and research centers to the private sector and society. In this sense, new agile European Public-Private Partnership on AI, the network of European AI Digital Innovation Hubs and AI technology centers between academy and industry are essential to develop an European economy based on artificial intelligence that is aligned with the European ethical principles.

Prof. Asunción Gómez-Pérez

Vice-Rector for Research, Innovation and Doctoral Studies of the UPM

Machine Learning and Artificial intelligence together with Data will drive the next generation of applications in industry and the public sector and provide a shortcut to solving the development goals put forward by the UN. To meet and exceed the demand for competence and solutions, Europe must increase its investments in education and applied research. The establishment of a European Public-Private Partnership on AI is a powerful tool to make this happen when integrated into national initiatives like AI at RISE in Sweden.

Dr. Pia Sandvik

CEO, Research Institutes of Sweden

Having been the first European sector employer organisation to address the effects digitalisation has on the world of work in a structured way, it is Ceemet's believe that digitalisation, and all its forms such as AI, has to be human centric. It is not a new insight that skills, right-skilling, training, including of teachers, adapted curricula in education and -vocational- training are vital for rolling out digitalisation across Europe by creating competence, confidence and trust, so that AI, robotics, and data can fully unleash their potential to the good in a competitive Europe, that has chosen to underscore an ethical approach to AI, and beyond. Fear is not a good guide and whereas AI can be compared with a black box, it is careless to play with fears that more jobs will be lost due to digitalisation than there would be created. Therefore, I appreciate this industry- and research-driven initiative by euRobotics and BDVA to address these issues.

Uwe Combüchen

Director General, Ceemet

Autonomous AI systems must, just like humans, function within legal and ethical frameworks. Due to individual and cultural differences in those frameworks, you cannot leave that to the designers, suppliers or owners. This is a task for our European governments. But if these governments only prescribe what AI can and must do, the potential of AI will remain limited to what people can already do. The development of reasoning systems is a challenge for science and industry. Specifying goals and quantifying utility - what is the value of the different outcomes? - is a task for the government. A European AI PPP can play an important role in the necessary corporation between governments, industry and research and technology organizations. Europe is well positioned in terms of system thinking, multidisciplinary approach and innovation to achieve meaningful control and thereby utilize the full potential of AI.

Professor Peter Werkhoven

Chief Science Officer and member of the Board of Management of TNO and full professor at Utrecht University

Data, Artificial Intelligence and Robotics are part of our present and will be more and more key elements of our future. We must define the scope of their use and protect them as they become part of ourself and of our society. Data but also threats, will increase with the evolution of technologies (5G, pervasive IoT, quantum computing ...): it is important to integrate from the beginning (by design) cybersecurity in the development of innovations in data, AI and robotics. For this reason, the cooperation between ECSO and the new European initiative on data, AI and robotics will be strategic for the development of our economy but also for the protection of our citizens and countries.

Dr. Luigi Rebuffi

Secretary General - ECSO

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Executive Summary

AI (Artificial Intelligence) presents an opportunity and a challenge to Europe, an opportunity to improve the operation of European public and private sectors and a challenge to translate Europe's core AI strengths into a global market advantage. The AI PPP (Public Private Partnership) is focused on **strengthening research into the market**, developing and extending **Europe's skill base** and **raising AI deployment**. It is likewise focused on the challenges AI brings, on new business models and stakeholders, on the need for AI to be trustworthy and secure and the need for citizens to see direct benefit from its use.

This is built on the work of two associations, BDVA and euRobotics, and it is their joint effort that is presented in this SRIDA (Strategic Research, Innovation and Deployment Agenda). Both associations are committed to working closely together to see this SRIDA implemented **by building on the AI infrastructure and ecosystem** that Europe is creating with Digital Innovation Hubs, centres of excellence, data and AI platforms etc. Both see the benefit of a strong European AI and the advantages this will bring to businesses, citizens and the public sector.

The AI PPP will be **open and inclusive** and seeks to create a common view that enables success. It will create impact by focusing on strategic areas that are core to delivering AI in Europe. Through **mobilising the ecosystem the AI PPP** will provide strong leadership that is rooted in the widespread deployment of AI in sectors and regions across Europe. It will **build on European strengths** to develop a **global AI position** that aligns with fundamental European values and delivers technology, products and services that maintain this by seeking to align academic excellence and innovation to the needs of both industry and citizens.

One of the core activities of the AI PPP will be to create connectivity across the AI ecosystem. AI thrives on connecting all stakeholders. Increasing connections will result in improved **academia-industry collaborations** built on a foundation of academic excellence grounded by industrial relevance. Connectivity will **engage member states and regulators** into the ecosystem and researchers and innovators into the market. It will develop new business and new forms of investment. It will create dialogues that address fundamental issues around deployment and citizen trust in AI and will create new partnerships.

A key impact will be the **stimulation of industrial investment and private funding** for AI in Europe that raises the success of innovators translating research to market. The AI PPP is committed to the development of a rich AI innovation ecosystem in Europe that is built around a **strong skills pipeline, excellent research** and **effective regulation and standards** coupled to best practice in each sector. The AI PPP will provide the **focal point for AI in Europe**.

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The Vision of the AI Public Private Partnership is to boost European industrial competitiveness and lead the world in developing and deploying value-driven trustworthy AI based on European fundamental rights, principles and values.

Motivation and Context

The European Commission's Coordinated Plan on Artificial Intelligence[1] highlights the importance of AI for Europe and calls for the development of an industrially led AI PPP triggered by the Big Data Value Association (BDVA) and the European Robotics Association (euRobotics) through the joint action of their respective cPPPs. In December 2018, at the Vienna ICT Conference, BDVA and euRobotics signed a Memorandum of Understanding and committed to developing a new AI PPP[2].

This partnership is built on two well-established associations representing over 400 European organisations from Industry and Research[3]. Both PPPs in Data and Robotics have proven to be effective in mobilising private investments and have created the critical assets and infrastructure needed for boosting AI in Europe. Each recognises the mutual value in building a new partnership. Both are focused on achieving impact in the market, and both understand the need to stimulate the uptake of AI across all business sectors and between industries to maximise the gain for Europe. Both associations understand that each brings the other a significant advantage in terms of impact.

euRobotics and BDVA published a common vision document[4] in March 2019 for the AI PPP. This vision emphasises the importance of connecting and aligning the key stakeholders in the AI Ecosystem; businesses, researchers and policymakers across Europe.

The AI PPP is open and inclusive and seeks to create a common view that enables success in Europe, including the member states. The first consultation release of the SRIDA sets out how to bring about this vision in practical terms by collaborating with related research, vertical and technology networks. The partnership will exchange key ideas, objectives and challenges to build a common focal point for European AI.This second consultation release extends the first release by describing the way the AI PPP envisages open collaborations within the European AI ecosystem and its relation to horizontal and research partners.

The AI imperative

Throughout this document, the term Artificial Intelligence (AI) is used as an overarching term that covers both digital and physical intelligence, data and robotics, and related smart technologies. It encompasses both the impact of data and robotics, notably in combination, on the key stakeholders, such as businesses, citizens, governments and academia, and as a collective term for products and services that use AI techniques to improve competitiveness, user experience, performance, quality, etc.

1 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic, and Social Committee and the Committee of the Regions - Coordinated Plan on Artificial Intelligence (COM(2018) 795 final), 7th December, 2018.

2 "Artificial Intelligence: Public-Private Partnerships join forces to boost AI progress in Europe" https://ec.europa.eu/digital-single-market/en/news/artificial-intelligence-public-private-partnerships-join-forces- boost-ai-progress-europe

3 The combined membership of both associations represent Large Industry, SMEs, Research/Academic and Public and Non-for-profit. BDVA membership comprises of 28% SMEs, 16% Large Enterprise, 50% Research with the remainder public entities or non-profit. euRobotics membership comprises 19% SMEs, 13% Large Enterprises, 62% Research, and 6% associated members, such as regions or non-profit organisations

4 http://www.bdva.eu/sites/default/files/VISION%20AI-PPP%20euRobotics-BDVA-Final.pdf

To boost value-driven development, adoption and deployment of AI across European industrial sectors, the public sector, and society, **Europe needs an ambitious and efficient strategy** and associated mechanisms that can align user value and industrial offerings with research excellence in AI. Europe needs to accelerate all aspects of AI research, development, adoption and deployment and ensure that its skill base is prepared.

AI is transversal and cuts across sectors affecting many actors in the value chain. There is widespread acceptance that AI will have significant impact on all economic sectors[5] and on the United Nations' Sustainable Development Goals[6]. The successful implementation of AI can change or transform a wide range of jobs and impact existing value chains. To maximise the benefit of AI, stakeholders need to collaborate to develop new AI-driven offerings that are sustainable, efficient, fair and aligned with European fundamental values. These will integrate AI into the physical and digital worlds, improving decision-making, autonomy and human-interaction competences.

The AI PPP provides the focal point for the coordination of all stakeholders in the emerging European AI Ecosystem. It will create synergies between different communities and member states to optimise the impact of European investments in AI, data and robotics.

Key Impacts

The AI PPP is ambitious and realistic about what is needed to stimulate the uptake of AI and about how and where it can contribute. Its primary strength comes from aligning a broad range of stakeholders in an European AI Ecosystem, rooted in the integration of AI, robotics and data and in exploring synergies around the creation of joint market impact.

Impact will leverage existing public and private investment[7] in the innovation structures each association is involved in developing, such as data platforms, and the Digital Innovation Hub networks in robotics. The partnership provides an opportunity to combine and scale up the impact of these investments to create greater value for European business and society through the wide-spread deployment of AI.

The combined experience of the associations' membership reaches into every business sector, every region and the research community in Europe, an advantage that will leverage actions to deliver AI at a European scale. Achieving this needs more than a strong market and technology position, it needs a skilled workforce and a regulatory and standardisation landscape that can speed up deployment and enable markets to develop; it requires strategy and an understanding of best practice, it needs a single body that can consult, cohere and collate the requirements for AI at a European level. This partnership is dedicated to that goal.

5 *"Notes from the AI frontier: Tackling Europe's gap in digital and artificial intelligence"* McKinsey Global Institute February 2019

6 https://www.un.org/sustainabledevelopment/sustainable-development-goals/

7 The BDVA leverage ratio for 2017 is **6.95** (with 1,1 B€ mobilised private investments since the launch of the cPPP at the end of 2014) and for the euRobotics PPP (SPARC) it is **3.6**. Full details of the success and impact of the PPPs can be found in their respective Annual Monitoring Reports https://www.eu-robotics.net/sparc/upload/Monitoring-report-2017-final-SPARC-2018_5v0-with-annexes.pdf http://www.bdva.eu/sites/default/files/MR2017_BDV_PPP_Main%20Report_September%202018_1.pdf

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EUROPEAN AI OPPORTUNITIES

The AI opportunities in Europe are built around both its existing markets and new market opportunities that will be created by deploying AI into business and service sectors. There is evidence of investment in AI across European sectors but greater action is needed to realise the full AI value opportunity across all sectors. Strengthening the AI Innovation Ecosystem by connecting and engaging with AI stakeholders will allow the current barriers to adoption to be addressed. The AI PPP will work towards maximising the AI opportunities in Europe.

AI Market Opportunities

The current data explosion, combined with recent advances in analytical capability and computing power, advanced robotics and embedded AI pave the way for AI derived value to be captured by the market, providing value for industry and society. These technical advances enable new industrial and societal challenges to be addressed, foster the more rapid deployment of AI applications and have an impact on the transformation of traditional value chains.

These advances have increased the demand for AI systems in every sector, and agile businesses are starting to react and develop new markets. However, the spread of uptake has been restricted to specific applications and sectors, and the benefits of AI have yet to be deployed by all sectors and organisations. Global investment in AI is increasing, and according to IDC[8] worldwide spending in digitally based AI will reach $35.8 billion in 2019, an increase of 44% over the amount spent in 2018. By 2022, this amount is projected to more than double to $79.2 billion. The European share of industrial investments for this market is estimated at $5 billion, with a forecast growth to 2022 to $13 billion. Similarly, investment in robotics and drones will be worth $115.7 billion in 2019, of which about $13 billion will be in Europe[9].

In terms of verticals, IDC expects financial investment in all markets (see Figure 1). In other words, the message from investors is that AI is expected to add value across all sectors. This highlights that AI opportunities exist across all sectors and domains.

8 International Data Corporation (IDC), 'Worldwide Semi-annual Artificial Intelligence Systems Spending Guide, February 2019. IDC defines AI software technologies as a set of technologies that use natural language processing (NLP), image/video analytics, machine learning (ML), knowledge graphs, and other technologies to answer questions, discover insights, and provide recommendations.

9 IDC Worldwide Semi-annual Robotics and Drones Spending Guide -April 2019

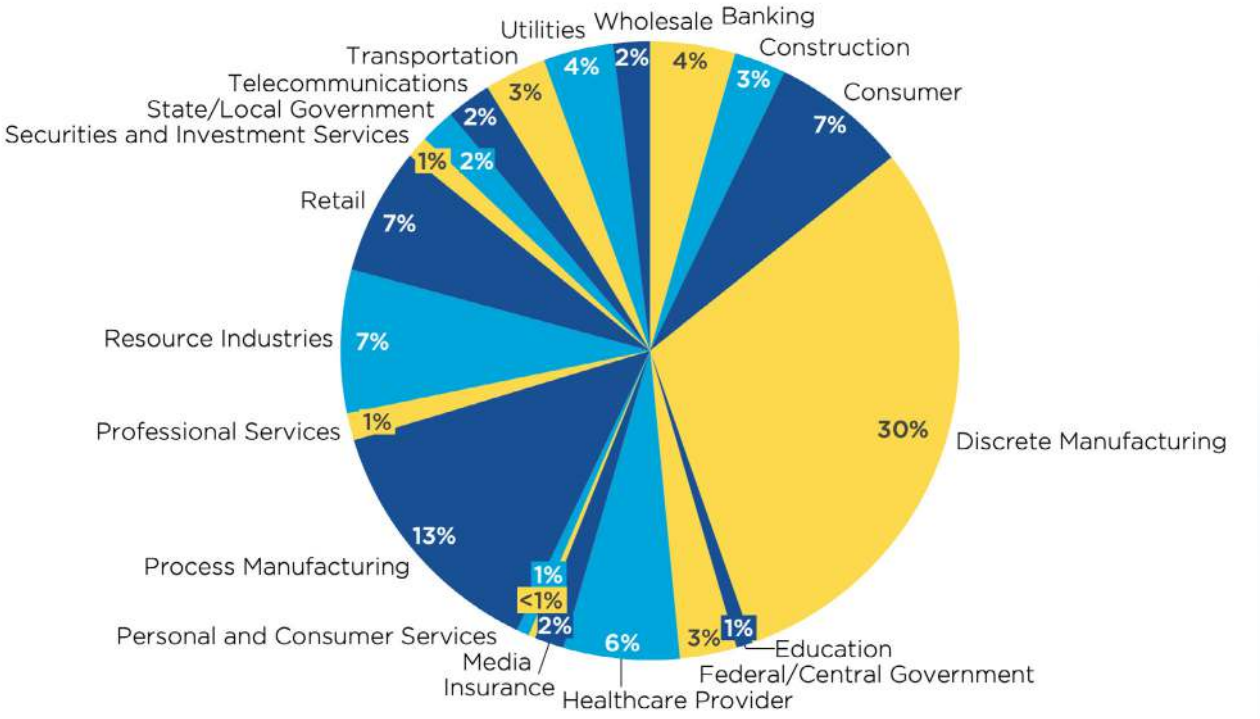

Figure 1: Expected distribution of financial investments in Artificial Intelligence systems, Robotics and Drones in Western Europe in 2019[10]

AI Value Opportunities

The deployment of AI will impact several main areas:

- By weaving AI into the design, manufacturing, production and deployment processes, *productivity* can be raised.
- By using AI to increase autonomy, *higher operational flexibility* can be achieved.
- By using AI to improve usability of products and services (e.g. by allowing greater variations in the human-machine interaction), the user value can be increased and *new customer segments addressed*, therefore creating new markets.
- By using AI for supporting complex decision-making processes in dynamic environments, people can get help in situations of rising complexity (e.g. technical complexity, increasing volatility in markets).

These fundamental impacts are felt at all areas in every market sector.

For instance, AI-powered digital technologies will benefit people and society by leading the way in the transformation of the **healthcare sector** including the transition to new care models and, notably, value-based healthcare. AI can ensure that care is seamless by delivering solutions across the health continuum. This ranges from helping people to take an active approach to healthy living and prevention; giving clinicians the tools to make first-time-right and personalised diagnosis, and creating new opportunities for intervention, treatment and supporting patient recovery when they return home.

In the area of **telecommunication**, interaction with humans can be complemented with AI to scale real-time support to a large number of customers. In addition, the management

10 Source: Combined data from IDC Worldwide Semi-annual Artificial Intelligence Systems & Robotics and Drones Spending Guide -2018 H2)

and optimisation of operations can be improved by predicting and adapting to future demands as well as by ensuring cybersecurity. AI analytics can help to improve performance, efficiency, resilience and scalability of telecommunication networks.

In **transport**, AI will impact both within the existing infrastructure but will also transform it. AI is already being used to identify the nature of journeys taken across a city, how flows of traffic change through the day and in different weather conditions. This has an impact on many different stakeholder groups, e.g. city planners learn how to improve the traffic flow and individuals can optimise their travel journey. AI also stimulates new businesses based on real-time traffic data that can reshape the city by on-demand transport services replacing personally owned vehicles, by enabling smaller swarms of delivery vehicles and by the removal of carparks from town centres.

There is a similar story that can be told in each area of application. For example, in **manufacturing and production** AI delivers productivity gains through more efficient resource, energy and material use, through better design and manufacturing processes and inside products and services, enhancing their operation with more refined contextual knowledge.

In other sectors such as, agriculture, marketing, entertainment and in the service sectors, such as financial services, public services etc., and many others, the impact of AI is equally far-reaching.

In examining the vertical sectors where AI has impact it is important to also identify Europe's significant strengths and where there is a strategic priority for Europe. This will help to distinguish European AI and identify unique opportunities in the global market.

It is essential that Europe builds on its unique strengths; its strong academic base, its Business to Business expertise and its market leverage on a global scale. AI that is based on core European values will improve trust and acceptance in society that will in turn create a stronger market for AI. Europe's comprehensive public sector provides a great opportunity to deploy AI in areas that will increase its value to citizens. All of these factors demonstrate that there is a significant opportunity to deploy AI in Europe and **Europe must now quickly act to maximise the benefit**.

Challenges for the Adoption of AI

To generate and capture value in these markets, there are numerous challenges that must be addressed:

- **Fragmented Research Landscape:** Europe has a strong AI research capability in academia and public research organisations. However, their activities are fragmented between sub-communities and within member states[11]. This makes it more difficult for European organisations to translate research excellence into innovative AI solutions that can impact across regions and globally.
- **Higher Complexity of AI in Industry and Public domain:** Implementing AI, data and robotics in industrial and public environments relies on incorporating the domain knowledge of underlying processes. Handling these challenges requires combining domain specific process knowledge with AI based knowledge.
- **Lack of Skills and Know-How:** Many European organisations lack the skills to

11 European Artificial Intelligence. (AI) leadership, the path for an integrated vision". Policy Department for Economic, Scientific and Quality of Life Policies, Directorate-General for Internal Policies. Laura DELPONTE (CSIL) 2018

manage or deploy AI solutions[12]. A global competition for AI talent is underway. Regions with the most vibrant AI landscape are better positioned to attract skilled professionals.

- **AI Policy and Regulation Uncertainty:** Policy and regulation of AI is still unclear in areas including liability, right to explain, and data access. Many organisations have concerns on compliance.
- **Societal Trust in AI:** There are many misconceptions and much misinformation about AI systems in societal debates, and the technology seems not to be fully accepted by society in all application areas.
- **Building a Digital Single Market:** Europe has to increase its digitalisation effort to keep its leading position in several verticals and to support every member state to be strong in future technologies.[13]
- **Access to AI Infrastructure:** Both academics and innovators (SME's and start-ups in particular) need good access to world class innovation infrastructure including access to data and resources such as HPC and test environments, etc.
- **Technological Barriers:** There is considerable complexity and cost in creating AI systems with the ability to collect, process, and analyse large quantities of data in order to make robust and trustworthy decisions and implement autonomy.
- **EU private investment environment:** Still lagging behind other parts of the world, Europe needs to create a competitive, forward-looking private investments eco-system, to boost innovation in AI in a fast and focused way.

A successful strategy to overcome these challenges requires collective action from all stakeholders working together in an effective AI Innovation Ecosystem, this can be stimulated by the AI PPP.

European AI Innovation Ecosystem

The European AI Innovation Ecosystem is complex and diverse. It contains multiple types of stakeholder and, to be effective, there needs to be alignment and collaboration between them. It is the "agora" for the sharing of assets, technology, skills and knowledge. It provides scale to achieve consensus and critical mass around the development of AI value through innovation that **no single partner alone** could achieve. It expresses the collaborative purpose that binds organisations and individuals together in achieving success in deploying AI. The Ecosystem is typically composed of:

- **End User:** Person or organisation from different sectors (private and public) that leverage AI technology and services to their advantage.
- **Application Provider:** An organisation that uses AI technology for developing a vertical AI application (e.g. to be offered as AI service).
- **User:** A person who either knowingly or unknowingly uses or is impacted by a system product or service that uses AI.
- **Data Supplier:** Person or any organisation (public or private) that creates, collects, aggregates, and transforms data from both public and private sources.

12 IDC's Western Europe AI/Cognitive Solutions Survey, June 2018

13 McKinsey Global Institute. Notes from the AI Frontier: Tackling Europe's Gap in Digital and AI, Discussion Paper, February 2019

- **Technology Creator:** Typically, an organisation (of any size) that creates tools, platforms, services, hardware, and technical knowledge.
- **Broker:** an organisation that connects the supply and demand for AI assets (such as skills, data, algorithms, infrastructures, etc.) needed for developing AI applications by providing a channel for exchanging AI assets.
- **Innovator, Entrepreneur:** Drives the development of innovative AI technology, products, and services.
- **Researcher and Academic:** Researches and investigates new algorithms, hardware, technologies, methodologies, business models; provides skills and training in AI and assesses the societal aspects of its impact.
- **Regulator:** Assesses AI systems for compliance with regulation, privacy, and legal norms.
- **Standardisation Body:** Defines technology standards (consensus-based, de-facto and formalised) to promote the global adoption of AI technology.
- **Investor, Venture Capitalist:** Provides resources and services to develop the commercial potential of the ecosystem.
- **Citizen:** A person who will or will not develop trust in AI technologies.

An effective European AI Innovation Ecosystem facilitates the cross-fertilisation and exchange between stakeholders that leads to new AI-powered value chains that can improve business and society and deliver benefits to citizens. **A productive European AI Innovation Ecosystem is an essential component to overcome the key adoption challenges.**

eu ROBOTICS

BDV
BIG DATA VALUE
ASSOCIATION

DRIVING AI ADOPTION

Deploying AI successfully in Europe requires an integrated landscape for its adoption and the development of AI based on Europe's unique characteristics.

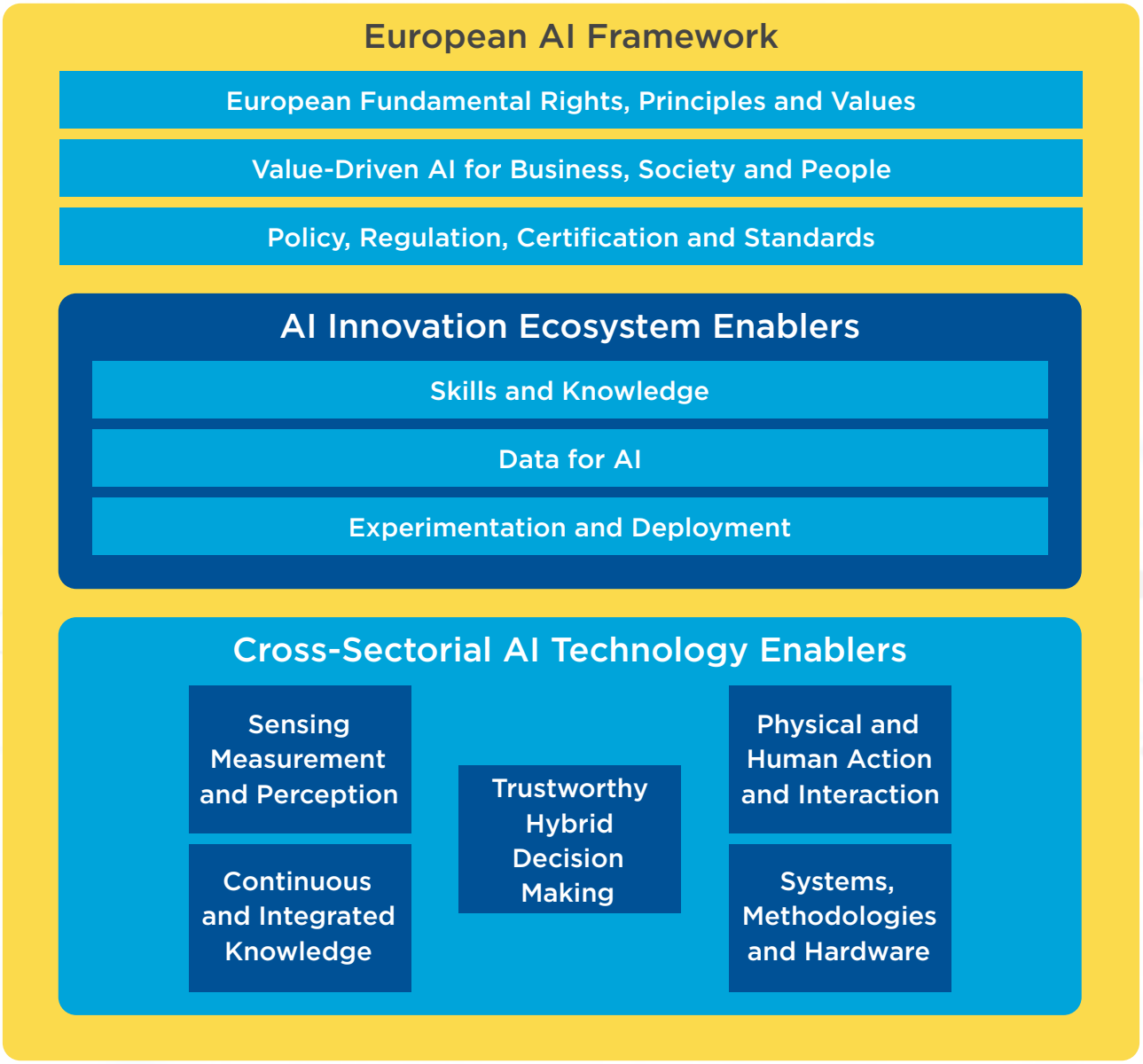

Figure 2: European AI Framework and Enablers

Figure 2 sets out the context for the operation of the AI PPP. It clusters the primary areas of importance for AI research, innovation and deployment into three overarching areas of interest. The *European AI Framework* represents the legal and societal fabric that underpins the impact of AI on stakeholders and users of the products and services that businesses will provide. The *AI Innovation Ecosystem Enablers* represent essential ingredients for effective innovation and deployment to take place. Finally, the *Cross-Sectorial AI Technology Enablers* represent the core technical competencies that are essential for the development of AI systems.

European AI Framework

AI works within a broad framework that sets out boundaries and limitations on its use. In specific sectors, such as healthcare, AI operates within ethical, legal and societal contexts and within regulatory regimes that can vary across Europe. Products and services based on AI must be based on values that are compatible with European rights principles and values. Critical to deploying AI is its acceptance by users and citizens, and this acceptance can only come when they can assign trust. This section explores this *European AI Framework* within which research, design, development and deployment must work.

European Fundamental Rights, Principles, and Values

Context

On the one hand, the recent advances in AI technology and applications have fundamentally challenged ethical values, human rights and safety in the EU and globally. On the other hand, AI offers huge possibilities to raise productivity, address societal challenges and enhance the quality of life for everyone. The public trust in AI is prerequisite on it being trustworthy, ethical and secure and without public acceptance the full benefit of AI cannot be realised. The European Commission has already taken action and formulated in its recent communications[14] a vision for an ethical, secure and cutting-edge "*AI made in Europe*" designed to ensure AI operates within an appropriate ethical and legal framework that embeds European values.

Opportunity and impact of the AI PPP

The AI PPP has a unique ability to facilitate a multi-stakeholder dialogue that can expose challenges and define approaches to be explored and tested to make fundamental rights, principles and values actionable in practice. In doing so, the AI PPP can pave the way towards the operationalising of AI ethical guidelines and assessment frameworks. The AI PPP will also engage with citizens aiming to understand and minimise the apprehension surrounding AI-based technologies while seeking to improve trustworthiness and the public adoption of AI.

Concrete actions needed

The AI PPP will:

- Facilitate a multi-stakeholder dialogue[15] and consensus building around the core issue of trustworthiness by guiding and shaping a common AI agenda, and fostering research and innovation on trustworthy AI.
- Seek to promote a common understanding among stakeholders of European AI fundamental, rights and values, so that each sector and community are informed and aware of the potential of AI as well as the risks and limitations of current

14 Communication Artificial Intelligence of 25th April 2018 (see https://ec.europa.eu/digital-single-market/en/news/communication-artificial-intelligence-europe) and Communication Artificial Intelligence of the 7th December 2018 (see https://ec.europa.eu/commission/news/artificial-intelligence-2018-dec-07_en)

15 These activities will closely align with the work and accomplishments of the AI Alliance. The emphasize of the AI PPP aims to support the operationalisation, deployment and maintenance of the Trustworthy AI guidelines by helping to incorporate real-life feedback.th April 2018 (see https://ec.europa.eu/digital-single-market/en/news/communication-artificial-intelligence-europe) and Communication Artificial Intelligence of the 7th December 2018 (see https://ec.europa.eu/commission/news/artificial-intelligence-2018-dec-07_en)

technology and will develop guidance in the responsible implementation of AI.

- Establish the basis for identifying and expressing a European strategic viewpoint on rights, principles and values by providing clear links to relevant regulation, certification, and standardisation.

Capturing Value for Business, Society, and People

Context

Technical advances in AI are enabling real-world applications. These are leading to improved or new value-added chains being developed and integrated. To capture these new forms of value, AI-based solutions may require innovative business models that re-define the way stakeholders share investments, risk, know-how, data and consequently value. This alteration of value flow in existing markets can be disruptive and often requires stakeholders to alter their business models and revenue streams. These adjustments require new skills, infrastructure and knowledge and organisations may have to buy in expertise or share data and domain know-how to succeed. This may be particularly difficult if their underlying digitisation skills, a prerequisite for AI adoption, are weak.

Even incremental improvements carry risk and may create a reluctance to adopt AI. There may be little or no support for change within an organisation or value chain, especially when coupled to a lack of expertise. Successful adoption of AI solutions requires a flow of knowledge between the different stakeholders to develop a well-balanced and sustainable value network incorporating all stakeholders' interests, roles and assets that build value.

Opportunity and impact of the AI PPP

The role of the AI PPP is to mobilise industry and stakeholders in identifying how to build value from AI. As a focal point for AI in Europe, it will use its strategic influence and position, to foster and propagate a European approach to AI that addresses the challenges. It will work with the existing ecosystem to support and enable the deployment of products, processes and services that create value. The goal is to generate stimulating collaborations that foster the discussion around concrete new business opportunities. This is achieved by mapping the technical capabilities of the supply side to the specific end-user needs on the demand side and guiding AI innovation stakeholders towards assets, infrastructure and collaborations necessary for success.

Concrete actions needed

To support the adoption of AI applications, the AI PPP will stimulate discussions to align supply and demand perspectives of the diverse AI value stakeholders. With the main focus on application areas and sectors that:

- Are crucial for the European economy.
- Relate to critical infrastructure.
- Have a social or environmental impact.
- Can increase European competitiveness in AI.

Policy, Regulation, Certification, and Standards (PRCS)

Context

The adoption of AI depends on a legal framework of approval built on regulation, partly driven by policy, and an array of certification processes and standards driven by industry. As AI is deployed successfully in new market areas, regulation and certification can lag behind thereby creating barriers to adoption.

Similarly, a lack of standards and associated certification and validation methods can hold back deployment and the creation of supply chains and therefore, slow market uptake. In some areas of AI, the market will move ahead and wait for regulation to react, but in many application areas existing regulation can present a barrier to adoption and deployment. Most notably in applications where there is close interaction with people, either digitally or physically, or where AI is operating in safety or privacy critical environments.

PRCS issues are likely to become a primary area of activity for the AI PPP. Increasingly it is regulation that is the primary lever for the adoption of AI-systems. Similarly, the development of standards, particularly around data exchange and interoperability will be key to the creation of a European AI market place. Establishing how to certify AI will underpin the development of trust that is essential for acceptance and therefore adoption.

Opportunity and impact of the AI PPP

The AI PPP will act as a focal point for PRCS issues; its primary role will be as a connector and convenor of groups to address key issues. Its wide connectivity to stakeholders will allow it to bring different parts of the PRCS spectrum together and to identify synergies and cross-cutting opportunities that can attract a critical mass. In this, there will be both long and short term objectives. In the short term, it can connect stakeholders around critical issues and support the development of viewpoints and approaches. In the longer-term, it can support and develop stakeholder communities able to drive standards and processes that will be needed for the mass deployment of AI. Critical to this is the coherence of industry around PRCS issues and the embedding of PRCS into research agendas so that emerging technology is already aligned with standards and regulation. In addition, the AI PPP also has a role to highlight regulation that creates or has the potential to create barriers to innovation in AI.

Concrete actions needed

The AI PPP will need to carry out the following activities to progress PRCS issues:

- Identify key stakeholders in each area of PRCS and ensure there is good connectivity between them and to the AI Ecosystem.
- Work with stakeholders and the emerging AI ecosystem infrastructure (Digital Innovation Hubs, pilots, data spaces, etc.) to identify key issues that impact on adoption and deployment in each major sector.
- Promote best practice in deployment regarding PRCS issues and provide signposts to demonstrators and processes that can accelerate uptake.
- Support and collaborate in standardisation initiatives, and the harmonisation of

regulation across Europe to create a level AI single marketplace[16] and connect with European and Global standards and regulatory bodies.

- Foster the responsible testing of AI innovation in regulatory sandbox environments.
- Consolidate recommendations towards policy changes and provide support for related impact assessment processes.
- Drive European thinking and needs towards international standardisation bodies.

AI Innovation Ecosystem Enablers

The *AI Innovation Ecosystem Enablers* are essential ingredients for success in the innovation system. They represent resources that underlie all innovation activity across the sectors and along the innovation chain from research to deployment. Each represents a key area of interest and activity for the AI PPP, and each presents unique challenges to the rapid development of European AI.

Skills and Knowledge

Context

AI will affect skills needed by both industry and wider society. Typically, users of AI-based systems will be people without a background in statistics or mathematics or computer science. In order for AI to be acceptable to society, we need to ensure non-expert users have a basic understanding and awareness of AI systems and how they operate. This is required in order to avoid the misuse and misunderstanding of AI and ensure that people can accept and trust AI-based solutions.

As traditional industry sectors undergo an AI transformation, so too must their workforces. There is a clear skills gap when it comes to AI. However, while there are shortages of people with specific technical skills or domain knowledge there is also the need to train interdisciplinary experts. AI experts need insight into the ethical consequences posed by AI, by machine autonomy and AI augmented processes and services, they need a good understanding of the legal and regulatory landscape, for example, GDPR, and the need to develop and embed trustworthiness, dependability, safety and privacy through the development of appropriate technology, products and services.

Opportunity and impact of the AI PPP

In sectors and domains where AI will have strong impact, the AI PPP will seek to understand and propagate best practice on collaborative change. The specialisation required by AI practitioners will deepen as the sophistication of leading-edge tools and algorithms increases. The skills for general workers will become broader with an increased need for AI fluency built on enhanced IT skills and improved numeracy and statistics. The ability to judge bias in both data and algorithms will necessitate transdisciplinary training for knowledge workers. The delivery of AI skills to SMEs will also be necessary. Education systems, businesses, governments and social partners will need to adapt to the changing landscape[17].

16 For example the regulations around healthcare data vary considerably from country to country in Europe as do the approaches to the use of image capture in public places.

17 "AI: THE FUTURE OF WORK? WORK OF THE FUTURE!", Michel Servoz, European Commission (2019)

Concrete actions needed

The AI PPP will work through its network to ensure that all stakeholders along the value chain, including citizens and users, have the understanding and skills to work with AI enabled systems, in the workplace, in the home and online. The AI PPP has a critical role to play in bringing together the key stakeholders; academia, industry, professional trainers, formal and informal education networks and policymakers. These collaborations will need to examine regional strengths and needs in terms of skills across the skill spectrum, both technical and non-technical. It is critical to ensure that the skill pipeline is maintained to ensure the AI transformation of Europe is not held back. Some concrete actions the AI PPP will focus on:

- Promote equality and diversity within the current and future workforce to ensure diversity and balance in the educational opportunities that drive the skill pipeline.
- Work towards the alignment of curricula and training programmes for AI professionals with industry needs.
- Establish AI skills recognition, both technical and non-technical, through certification mechanisms for university courses, professional and vocational training, and informal learning.
- Development of complementary short-courses related to AI aimed at decision-makers in industry and public administration, and those wishing to upgrade, enhance or acquire AI based skills.
- Support for secondary, or earlier, education and adult learning to cover STEM skills including ethics, social, and the business aspects of AI together with the changing nature of work as well as support for vocational training.
- Develop citizen engagement to raise awareness of AI and its impact and provide realistic demonstrations of its capabilities and limitations.

Data for AI

Context

For AI technology to develop further and meet expectations, large volumes of cross-sectoral, unbiased, high-quality and trustworthy data need to be made available. Data spaces, platforms and marketplaces are enablers, the key to unleashing the potential of such data. There are however important business, organisational and legal constraints that can block this scenario such as the lack of motivation to share data due to ownership concerns; loss of control; lack of trust; the lack of foresight in not understanding the value of data or its sharing potential; the lack of data valuation standards in marketplaces; the legal blocks to the free-flow of data and the uncertainty around data policies. Additionally, significant technical challenges[18] such as interoperability, data verification and provenance support, quality and accuracy, decentralised data sharing and processing architectures, and maturity and uptake of privacy-preserving technologies for big data have a direct impact on the data made available for sharing[19].

18 Details about the technical challenges are covered in the "Continuous and Integrated Knowledge section"

19 Additional information on challenges at technical, business, organizational, legal compliance, EU-cooperation level can be found in: "Towards a European Data Sharing Space: Enabling data exchanga and unlocking AI potential". http://www.bdva.eu/sites/default/files/BDVA%20DataSharingSpace%20PositionPaper_April2019_V1.pdf

Opportunities and impact of the AI PPP

Alignment and integration of established data sharing technologies and solutions, and further developments in architectures and governance models aiming to unlock data silos, would enable data analytics across a European data sharing ecosystem[20]. This will enable AI-enhanced digital services to make analysis and predictions on European-wide data, thereby combining Data and Service Economies. New business models will help to exploit the value of those data assets through the implementation of AI amongst participating stakeholders including industry, local, national and European authorities and institutions, research entities and even private individuals.

Concrete actions needed

The AI PPP will:

- Create the conditions for the development of trusted European data sharing frameworks to enable new data value chain opportunities, building upon existing initiatives and investments (data platforms, i-spaces, big data innovation hubs). Data value chains handling a mix of personal, non-personal, proprietary, closed and open research data need to be supported.
- Promote open datasets and new open benchmarks for AI algorithms, subject to quality validation from both software engineering and functional viewpoints.
- Define specific measures to incorporate data sharing at the core of the data lifecycle for greater access to data, encouraging collaboration between Data Value Chain actors in both directions along the chain and across different sectors.
- Provide supportive measures for European businesses to safely embrace new technologies, practices and policies.
- Facilitate coordination and harmonisation of Member States efforts and realise the potential of European-wide AI-digital services in the face of global competition.
- Guide and influence standards in relation to tools for data sharing, privacy preservation, quality verification, collaboration and interaction.
- Promote standardisation at European level but maintain collaboration with international initiatives for made-in-Europe AI to be adopted worldwide.

Experimentation and Deployment

Context

Experimentation is a critical for AI-based innovation because of the need to deploy in complex physical and digital environments. This includes safe environments for experimentation to explore the data value as well as to test the operation of autonomous actors. AI-driven innovations rely on the interplay of different assets, such as data, robotics, algorithms and infrastructure. For that reason, *cooperation* with other partners is central to gaining access to required assets. This includes access to the AI ecosystem covering AI platform providers, data scientists, data owners, providers, consumers, specialised consultancy, etc.

20 that includes research centres`, industry, government and multi-national bodies, by leveraging existing pan-European initiatives, platforms and networks

Opportunity and impact of the AI PPP

The partnership will stimulate the development of experimentation environments and sandboxes where companies and researchers, including SMEs, can test their AI based services and products efficiently and sufficiently prior to market deployment. Access to these testing environments is a key part of the offering from AI Digital Innovation Hubs, including the provision of infrastructure, technical support, skills, data, etc. including incubation and acceleration services. These enable companies to rapidly develop new businesses based on AI technologies, applications and models.

Concrete actions needed

The AI PPP will:

- Stimulate cooperation between all stakeholders in the AI value chain around experimentation and deployment.
- Enable access to infrastructure and tools together with data sets covering the whole value chain as a basis for doing experiments to support development and deployment.
- Support the creation and linking of DIHs, centres of excellence and all other EC initiatives on the AI infrastructure.
- Support AI-based incubators as well as testbed developments as well as promote initiatives that enable SME access to infrastructure and tools at low cost.
- Foster set-ups that bring together industrial user with research excellence, domain experts with data scientists, aiming to fill the gaps between domain/business and technical expertise.

Cross-Sectorial AI Technology Enablers

The following sections detail each of the *technology enablers* and illustrate their inter-dependence in building successful AI products and services. Each technology enabler needs to work in unison to achieve optimal function and performance. They represent the fundamental building blocks needed to create AI systems of all types.

The *Sensing, Measuring and Perception and Continuous and Integrated Knowledge* technology enablers create the data and knowledge on which decisions are made. These are used by the *Trustworthy Hybrid Decision Making* technologies to deliver; edge and cloud-based decision making, planning and decision systems, and the high and low-level decision making that surrounds AI operating in complex environments.

Physical and Human Action and Interaction covers the challenges of human interaction, machine to machine inter-operation and machine interaction with the human environment. Complex challenges that range from the optimisation of performance to safety and social interaction with humans in unstructured and multilingual environments.

The *Systems, Methodologies and Hardware* technology enabler provides the technologies that enable the construction and configuring of systems, whether they are based purely on data or based on autonomous robotics. These tools, methods and processes integrate technology into systems and are responsible for ensuring that core system properties and characteristics such as safety, robustness, dependability and trustworthiness can be integrated into the design cycle, tested, validated and ultimately certified for use.

One of the core characteristics that AI enabled systems need to display is trustworthiness. Building systems that can be trusted is critical to their acceptance and therefore to successful deployment. Although only some critical AI applications need high levels of trustworthiness all applications need to be trustable. Trustworthiness must be designed into an AI system but no single technology embodies it, only the interaction between technology building blocks creates it. Trustworthiness is built on multiple underlying system characteristics; reliability, dependability, safety, etc. and on the behaviour displayed by the system during its operation.

Each technical area overlaps with the next, there are no clear boundaries, indeed exciting advances are most often made in the intersections between these five areas and the system level synergies that emerge from the interconnections between them.

Sensing, Measuring and Perception

Overview

Sensing, measuring and perception technologies create information needed for successful decision making, control, and learning. They encompass methods to access, assess, convert and aggregate signals that represent real-world parameters into communicable data assets. They cover the development of sensing and processing methods, and the architecture of sensing systems. They create filtered and managed data streams and fill data stores and provide meta-data contexts. They address the parameters of acquisition, speed, resolution, range and quality and the technologies used to combine and fuse data to deliver an accurate picture of the world, be that from a website, a moving vehicle, a factory process or the reactions of people watching a TV advert.

Within this technology enabler, the digital and physical become inseparable. This is the crossover point between the physical world and its digital representation. Digital representations of, physical motion, visual images, text, sounds, haptics, chemistry and the human body are all fundamental to AI building a data representation of the world around us. Measuring grounds sensing through calibration to frames of reference, while perception builds information into data assets that can be communicated, shared and utilised by AI; this process is built on data:

- Gathered from sensors[21], often in real time.
- Acquired from measurement systems.
- Extracted from accumulated time series.
- Extracted from text, video, image and sound input.
- Referenced from data stores.

Dependencies

While the development of novel sensors mostly comes from outside the AI community, mainly from the materials and semi-conductor industries, the definition of data flows, interfaces and standardised meta-information, and the specifications for processing

21 A sensor is a physical device that detects or measures a physical property. Examples are cameras for images and video, microphone for sound, keyboard for text, a shaft encoder for rotation, or an accelerometer for motion.

methods and operational parameters such as range, sensitivity etc. are often unique to the needs of AI. AI applications also place constraints on data capture and processing, for example, on energy consumption or data accessibility where privacy is important.

	Continuous & Integrated Knowledge	Trustworthy Hybrid Decision Making	Physical & Human Action & Interaction	Systems, Methodology & Hardware
Sensing, Measuring and Perception	Provides these with processed sensed data and measurements	Provides these with context information	Provides data streams for interaction and closed control loops	Depends on architecture and data flow standards for perception processing and data asset exchange

Sensing, measurement and perception technologies are used across all sectors and draw on core technologies from a wide range of industry supply chains related to semi-conductors, materials, embedded systems, signal processing and metrology. AI is dependent on timely, high-quality data that is rich in information and reliable.

Challenges

The following high-level application driven challenges exist in this technology enabler:

- The development of faster more accurate methods of perception that cover all types of data modalities (text, video, image, sound, sensor, etc.) and that can operate across a wide range of environmental conditions; different weather, diverse everyday objects, different human emotions and ages, different behaviours and diverse human interactions.
- The development of active perception technologies that use cognition to guide the perceptual process; for example, prior knowledge and expectations can be used to focus sensing, for example, image interpretation may support text understanding, video may contextualise sound processing.
- The modularisation and standardisation of sensor interfaces, meta-information models and data flows; for example interfaces that can adapt to the balance between processing within the sensor (e.g. edge) and processing centrally (e.g. cloud); or handle both local and distributed data capture; or adapt processing methods to changing operating conditions or dynamics.
- The development of novel sensing and sensor systems for AI; for example in challenging environments; low and high temperature, pressure or in corrosive and explosive atmospheres, bio and chemical sensing, bio-compatible sensors and low cost, low energy, high accuracy sensors.
- The development of methods to validate and certify sensor systems for safety, privacy, trustworthiness, etc.; for example, safety certifiable sensors for human-robot interaction, body pose detection or in-vivo physical interfaces.
- The development of advanced sensors able to adapt and self-calibrate, zero-energy sensor and sensors that can be embedded in retail packaging, bridges or people.

Outcomes / Expected Impact

Better and smarter sensing, measurement and perception, will result in more accurate and timely decision making, improved perception of operating conditions and environments.

Wearable and embedded sensing will improve human interaction and the interaction of AI with objects and infrastructure. Distributed sensing linked into networks, for example, in connected autonomous vehicles, will create a broader spectrum of information from which AI can make better decisions. Improved accuracy and speed will improve control systems and automation and allow greater levels of autonomy.

Short Term	Medium Term	Longer Term
Standardised and modular sensors will create cross-sector supply chains and reduce costs Sensors and sensor systems will become cheaper to manufacture with better data quality; designs will become more compact and integrated Improved text, image, video, sound and sensor processing	The ability to modularise and fuse information from distributed and multi-modal sensor systems will become more standardised Greater integration of sensing and processing in modular packages Secure and intrinsically safe sensing systems Advances expected in chemical and bio-based sensing triggered by medical applications Improved accuracy through advances in active perception technologies	New materials and processing techniques will yield new forms of sensing and data acquisition Low or zero energy systems based on ambient energy Self-configuring and adaptive sensors IoT supported by ubiquitous networks of AI-based sensors Newly emerging sensing principles

Continuous and Integrated Knowledge

Overview

Continuous and Integrated Knowledge makes the sensing, measurement and perception data assets amenable to use in decision-making. This involves transforming, cleaning, storing, sharing, modelling, simulation, synthesising and extracting insights. By combining data-driven and knowledge-based models, it becomes possible

- to close the loop from data-driven, automated analytics and decision support to fully automated enactment and actuation of decision, a significantly *higher level of automation and reliability of processes* becomes possible.
- *to enable safe and reliable AI* functionalities, such as navigation and tracking of autonomous robots in a wide range of applications including autonomous cars, drones, delivery of goods and monitoring.
- to have a sustainable *digital twin* along the complete lifecycle (product and production) that provides value to AI data integration.

This enabling technology can be divided into different areas:

- Improving the data assets by addressing data pre-processing challenges for the various data types (including unstructured data such as image, text, video, audio, etc. and real-time data). This includes methods for annotation of unstructured data sources, unbiased and representative input data, methods for handling volumes of real-time data with high velocity, etc. Generating of *enriched and high-quality input* data for analytic applications. This includes any methods in advanced analytics and learning techniques to derive insights, patterns, events, data anomalies detection,

sentiment and emotion analytics, etc. from heterogeneous data sources, advanced learning techniques.

- ***Generating*** *domain related* **knowledge representations** *establishing the basis for seamless incorporation of background knowledge into AI applications*. This includes approaches that combine data-driven learning with symbolic approaches (hybrid AI), simulation technologies and digital twins, methods that enable the data processing at the location where the data is produced (edge analytics) and methods for knowledge representation learning.

Dependencies

The development of continuous and integrated knowledge establishes the basis to incorporate knowledge from the domain, physical environment, underlying processes and other interrelations into the analytical process. It is an important pre-processing step enabling the transforming of data assets into high quality input for trusted hybrid decision making.

	Sensing, Measuring & Perception	Trustworthy Hybrid Decision Making	Physical & Human Action & Interaction	Systems, Methodology & Hardware
Continuous & Integrated Knowledge	Enrichment of raw data to high quality data	Provides pre-processed data in high quality	Provides formal representation of physical world and context information guiding the interaction	Depends on architecture and data flow standards

Challenges

The following high-level application driven challenges exist in this technology enabler:

- The *scaling and federation of AI systems* ensuring that simple AI-models can seamlessly be composed and combined into large scale federated systems. This includes scenarios based on distributed data storage locations, for *data-in-motion* and *data-in-rest* while satisfying the privacy, robustness and performance requirements from the user side.
- The development of *data augmentation* methods for transforming data assets into high-quality and augmented training data. This includes the automated generating of data labels, the generation of synthetic data, automatic methods for data verification as well as methods to extract insights from small data.
- Methods for *knowledge modelling* and representation that enable the seamless integration of data and connection with the physical world. To support reuse of integrated and continuous knowledge its representation in standardises format.
- *Advanced learning methods* to ensure scalability and reusability of analytical outcome. This includes approaches for transfer learning, better online (e.g., continual lifelong) learning, meta-learning and knowledge representation learning.
- Methods that *integrate data-driven and knowledge-based approaches* to ensure that AI system use all the available sources of information, and that models trained by data are legible for humans and are compliant to given specifications.
- The development of methods for handling *security and privacy concerns*. This includes GDPR-compliancy in processing and sharing of data sources, ensuring

data privacy and data security standards along the data lifecycle which also applies to distributed data and real-time data.

Outcomes / Expected Impact

By incorporating more knowledge and reusing data assets, it becomes possible to optimise the creation of more complex AI applications leading to higher quality with lower construction effort.

Short Term	Medium Term	Longer Term
Provide automated data quality and filtering as input to AI components in order to avoid bias, imbalanced data Integrate domain knowledge into the data-driven data analytics process Ensure reliable data and transparency of input data Approaches for the automated generating of reliable training data	Means for the efficient semi-automated generation of domain knowledge models Scalable and seamless combination of analytical models Development of compact and secure and privacy-preserving algorithm for distributed data Extraction of valuable insights from small data Efficient means for transfer learning	Enable transparency by learning understandable models (open the black box) Intrinsically trustworthy knowledge modelling Hybrid knowledge representation Effective applications of model-based AI Support for human interrogation of AI decision making Development of intrinsically secure and privacy-preserving algorithm Reduction of the data demand for learning

Trustworthy Hybrid Decision Marking

Overview

Decision making is at the heart of Artificial Intelligence. Four scenarios can be considered where the different techniques within AI are used:

- *Human Decision Making*. When people interpret the output of AI-based systems to make decisions and take actions. For example in a manufacturing plant, the supervisor analyses the output of several predictive models in order to immediately stop the plant to repair a single machine or wait until the next scheduled maintenance stop. Here the consequences of the decision are assessed by a person or a team.
- *Machine Decision Making*. When actions are carried out autonomously by an AI-based system. For example, self-driving cars or drones. The consequences are assessed by the AI-based system.
- *Mixed Decision Making and Decision Support*. When decisions are agreed balanced between humans and machines. The consequences are evaluated taking into account the criteria of people (one person or a team) and the machine's criteria.
- *Sliding or Variable Decision Making*. When the balance between human and machine decision making varies during operation depending on machine based confidence levels or human interactions.

In all these scenarios different types of methods for decision making based on data and models should be taken into account, such as learning, optimisation and reasoning. In

addition, all scenarios rely on the quality of input data and knowledge, including symbolic and non-symbolic data.

Dependencies

Decision-making is at the centre of many AI-based systems. As such, it has many dependencies on other technologies that supply, process and store information.

	Sensing, Measuring & Perception	Continuous & Integrated Knowledge	Physical & Human Action & Interaction	Systems, Methodology & Hardware
Trustworthy Hybrid Decision-Making	Enrichment of raw data to high-quality data	Integrated high-quality, unbiased data for decision making (including domain knowledge)	Provides a formal representation of the physical world and context information guiding the interaction	Depends on architecture and data flow standards

Challenges

All three scenarios face combinations of the following challenges:

- *Timeliness*: ranging from decisions that must be taken immediately, in a matter of milliseconds, because the next steps/actions depend on every single decision (e.g. self-driving cars), to decisions that can be postponed with minimal risks or costs (e.g. predictive maintenance in production plants).
- *Robustness* ensuring that decision making maintains its level of performance under any circumstance.
- *Trustworthiness* increasing users' confidence in an AI System by making it dependable and reliable. To increase trust in AI systems, different aspects, such as transparency, explainability or controllability might be needed to be addressed.

The following high-level challenges exist in this technology enabler:

- *Interpretation of context*: Guiding machine or human to better understand the proposed recommendation / decision. This includes methods for providing explanations as well as methods ensuring interpretability of models.
- *Dealing with uncertainty*: Decisions must be taken in the face of uncertainty in the models, in perceptual data, and the effects of the system's actions. Resilient AI systems must be able to cope with incomplete and contradictory information by combining quantitative and qualitative methods.
- *Transparent anticipation*: Decision making often involves the use of predictive models to forecast possible futures and take anticipatory actions. To ensure trustworthy decisions, it must be possible for both the designers and the users to inspect, understand, validate and possibly challenge these models, as well as the criteria used to make a choice based on their predictions.
- *Reliability*: The challenge is to build decision making systems that prioritise the same option(s) for similar input consistently.
- *Human-centric planning and decision making* requires the incorporation of background knowledge and mental models of human users when deciding the best sequence of action as well as information of related processes, activities or tasks.

- *Augmented decision making* that complements human cognitive capabilities in a supportive way that humans are free to focus on less repetitive and more advanced tasks.

Outcomes / Expected Impact

By incorporating quality-controlled data within transparent decision-making processed AI-based decision making can be reliably incorporated into more sophisticated applications.

Short Term	Medium Term	Longer Term
Techniques for hybrid decision making Improve the human understandability of AI-produced decision Provide simple explanations detailing the rationale of a decision Ensure robust and reliable decision-making Increased transparency by estimating model uncertainty	Provide trustworthy and robust hybrid AI-based decision making Enable user dialogue to inform the user about the decision's rationale Efficient means for handling uncertainty in complex setting Reliable real-time decision making in dynamic and multi-actor environments Dependable decision making in safety and privacy critical environment Constraint-based planning and decision making in complex natural environments Planning and decision making under uncertainty	Explainable decision-making incorporating context information Intrinsically trustworthy decision making Human interrogation for decision making Adaptive decision-making by incorporation of environmental changes Human-centric and compatible decision-making by incorporation of social interaction and mental models

Physical and Human Action and Interaction

Overview

The technologies in this enabler embody every aspect of digital and physical AI working together. Interactions occur between machines and objects, between machines, between people and machines and between environments and machines. Interactions are shaped by real-time sensing, by stored information, by long term knowledge acquisition and multiple modalities and languages. At a more abstract level, humans interact, sometimes knowingly and sometimes unknowingly, with embedded AI, for example in financial or telecommunication systems. To achieve the seamless operation of AI digital and physical technologies need to work in harmony to achieve appropriate physical actions and interactions that respect their social, physical and environmental context.

Dependencies

The interaction technologies depend on both immediate data and embedded knowledge. There is also the need for regulatory compliance, especially when operating in close proximity to people. Interaction with people, particularly social interaction, is dependent on understanding the social norms of interaction, for example, when handing a screwdriver to someone on a ladder. Interaction also needs to adhere to privacy and ethical norms, both in digital and physical spaces.

	Sensing, Measuring & Perception	Continuous & Integrated Knowledge	Trusted Hybrid Decision Making	Systems, Methodology & Hardware
Physical & Human Action & Interaction	Depends on sensing of motion and mechanical properties Relies on perception for interaction Uses recognition of actions and sequences of interactions in people	Gets semantic knowledge around objects and human actions Gets data on objects and places	Depends on real-time context-aware decision making Trusted decision making	Depends on fast reactive architectures for control Relies on edge-based AI Requires assurance of safe operation and data privacy

These technologies have numerous technical dependencies, for example, on natural language processing, on-scene interpretation, on human interface technologies. They also depend on contextual data, models of interaction and semantic data about physical objects, for example, how best to grasp each of the objects in a warehouse.

Challenges

There are a set of core challenges in the interaction technologies that relate to the processing of environmental cues to guide the decisional autonomy that drives the sequences of individual actions that form an interaction. This can involve multiple sources of data and the interpretation of perceptions within the context of an interaction sequence. For example, interpreting the meaning of the spoken word in the context of an on-going interaction. Or understanding the consequence of detecting liquid in a container and the effect that might have on developing a grasping and movement plan. Within these generic interaction challenges, the following more detailed challenges also exist:

- The development of techniques and methods to achieve seamless and *natural interaction in unstructured contexts,* including multi-modal interaction and the development of generic interaction models.
- Improved *natural language understanding, interaction and dialogue* covering all European languages and age ranges.
- Development of *verbal and non-verbal interaction* models for people and machines, including gesture and emotion based interaction.
- The development of *interaction* technologies using *Virtual Reality (VR) and Augmented Reality (AR)* and their relation to human interaction both digital and physical.
- The *co-development of technology and regulation* to assure safe interaction in safety-critical and unstructured environments. This includes the development of actuators, mechanisms and control strategies for safe operation.
- The development of *confidence measures* for interaction and the interpretation of actions leading to explanations of interaction decisions and improved decision making.

Outcomes / Expected Impact

The expectation is that the further development of interaction technologies will lead to faster, more intuitive interactions that can take place over more extended time frames and

in multiple areas of competence. That social interaction can be carried out in a broader range of circumstances, linguistic and cultural context and that interactions can take place between multiple agents.

Short Term	Medium Term	Longer Term
Improved application specific multi-modal multilingual interaction Improved interaction based on perception of non-verbal and emotion cues Extended use of VR and AR in interactions Agreed safety criteria for co-working in production Increased augmentation of human task Affordable implementation of digital companion	Longer continuous meaningful multilingual interactions over periods of 10 minutes or more Generic standards for multi-modal interaction Safe, human compatible, physical and social interaction and collaboration in a limited range of tasks Improved dexterous manipulation of unknown objects Increased automation supporting human work	Continued interaction over extended time periods of hours Ability to carry out complex dexterous tasks autonomously Complex collaborative interaction between multiple agents Complex social interaction in multi-actor environments Human environment reconfigured around interaction Safe interaction in dynamic and uncertain environments

Systems, Methodologies and Hardware

Overview

AI systems are complex. They integrate diverse technologies, from software and hardware to physical structures. They can be distributed or local, large or small scale, they can operate unattended or have complex human interfaces. Designing, developing and deploying these systems has its own technology landscape and methodologies; support tools, system architectures, validation processes and modularity standards etc. These enabling technologies ensure that the designer, integrator and deployer can efficiently deliver AI systems that perform to specification. These enabling technologies cover:

- Software engineering methodologies (for AI, data and robotics).
- Systems engineering and integration science, including Systems of Systems development.
- Hardware systems architecture and design; mechanical, electrical, electronic, computational, sensing, actuation, control etc.
- Tools and processes for; design, deployment, testing, validation and certification etc.
- Modularity and Interoperability (Standards).

AI, and in particular autonomy, brings specific challenges to the construction of both digital and physical systems where they interact closely with people, especially vulnerable people, and in hazardous or critical environments. Here there is a strong expectation that the principle of "*... by design*[22]" can be extended to include ethics, privacy, trustworthiness etc. thereby delivering compliance and performance guarantees.

22 The concept of "... by design" covers the idea that, for example, safety, quality etc. can be built into a design through the design process.

Dependencies

These enabling technologies depend on standards and processes that have a global dimension. They provide the basis for quality assurance including trustworthiness, privacy etc. In some cases these may be set by legislation and regulation, particularly where AI systems interact with and affect people. In some critical environments the regulatory processes may determine the system architecture, and as regulation changes, architecture will be adapted to exploit or enact it.

	Sensing, Measuring and Perception	Continuous & Integrated Knowledge	Trusted Hybrid Decision Making	Physical and Human Action and Interaction
Systems, Methodology and Hardware	Sets constraints on digital and physical architectures	Provides knowledge used in model-driven design	Provides techniques for automated design processes	Sets constraints on digital and physical architectures

Challenges

At the core of *all challenges* in this enabling area is the need to develop, and guarantee that, systems meet a diverse range of system and behavioural design parameters. Parameters such as safety, trustworthiness, dependability; as well as technical parameters such as performance, latency, energy consumption, data use, processor power, communication bandwidth etc.

Achieving these diverse system level requirements requires tools, processes, architectures and standards that can be shown to build confidence that systems are fit for purpose. Efficient design and development processes lead directly to faster time to market, but the goal of right-first-time development remains a significant challenge for complex AI systems.

This fundamental challenge flows through all parts of the design, development and deployment cycle. The following high-level application driven challenges exist in this technology enabler:

- To develop tools that enable the design, development and deployment of AI systems that achieve their requirements at a behavioural level and a technical level through the design and development process.
- To develop system integration processes and methodologies that are cross domain and allow efficient system design that can deliver against Quality of Service criteria. In particular, these should integrate certification and validation criteria.
- To develop methodologies and processes that ensure that design and development consider the whole life cycle of a product or service, especially where the product learns to alter its behaviour over time and when it operates autonomously in unknowable environments. Existing exhaustive testing regimes are costly and act as a barrier to deployment; design-based autonomy assurance is a critical challenge.
- To develop system architectures and modular standards that encompass all aspects of data and physical systems. Critical to this is the co-development of data and physical standards of modularity, and the development of data standards for exchange and data asset generation that cover real-time, contextual, physical

digital contexts and their associated meta-data. Data architectures will have to appropriately balance between cloud functionalities and computing at the edge.

- To develop methods and metrics to evaluate the performance of AI systems, including the development of suitable benchmarks for complex, integrated and evolving systems.

Outcomes / Expected Impact

The primary outcome from improving these enabling technologies is the speeding up the development and deployment processes. Firstly, by improving the productivity of designers and system integrators and secondly by speeding up the testing and validation of designs. Discovering how to build "*... by design*" into tools and processes will enable performance and behaviour guarantees to be delivered.

Short Term	Medium Term	Longer Term
Data standards for exchange and meta data standards Platforms for data and algorithm sharing Testing and validation processes standardised Wide acceptance of definitions for dependability and trustworthiness Data quality standards Usability and human-machine interaction quality standards	Tools and processes that can more rapidly create AI systems with guaranteed performance Standardised trustworthiness AI architectures standardised and built into design tools System-level component modularity creating cross-sector supply chains Standardised knowledge models across domains	Stable design patterns across sectors Automated testing and soft validation of systems, including physical systems able to guarantee regulatory compliance Safety autonomous learning used in critical applications Assurance of autonomous systems in safety and privacy critical environments

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IMPLEMENTING THE AI PPP

The AI PPP will be open and inclusive and seeks to create a common view that enables success. Europe has excellent research and development, strong underlying innovation systems, worldwide leading verticals and an array of end-user markets able to capitalise on the growth that AI offers. The AI PPP will promote these strengths, to focus on technical development and create an environment in which AI can successfully impact on business, and society across Europe.

The AI PPP will work openly and collaboratively with AI-related organisations and communities all over Europe to create a common understanding and approach to AI that maximises the gain for Europe. The AI PPP will not replace any individual organisation.

The implementation of the AI PPP will target both the Digital Europe Programme to build up AI capacity & infrastructure and Horizon Europe for research & innovation. To this end, the AI PPP will be based on five strategic Working Areas (WA).

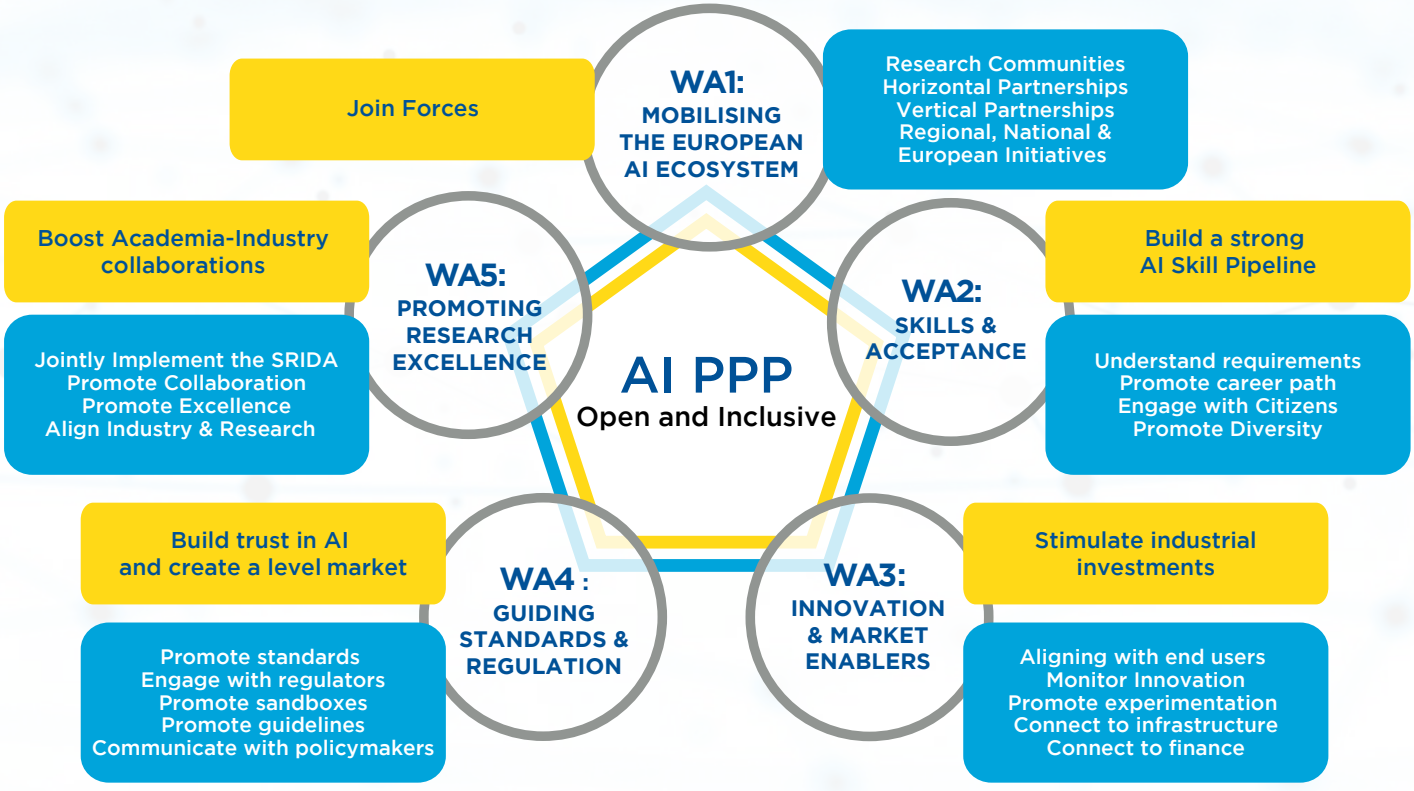

Figure 3: Summary of Work Areas

WA1: Mobilising the European AI Ecosystem

Objective

The AI PPP will first and foremost **act as a focus** for industry and service stakeholders, including researchers, who seek to access the opportunity offered by applying these new technologies. The **AI PPP will build a focal point for common AI strategy** development and implementation in Europe that is based on a good understanding of the unique European strengths and opportunities in AI ("*AI Made in Europe*") aligned with the European and global market opportunities for AI, as well as reflecting the landscape for AI adoption and deployment in Europe.

Action

The AI PPP will **mobilise the whole AI, data and robotics community** in Europe around the objectives of a common AI strategy. It will align with AI research excellence communities in AI to shape strategic challenges, with horizontal partnerships to strengthen synergies between technologies, with vertical partnerships to stimulate access to end-users. The AI PPP will connect with existing European initiatives, such as the European AI-on-demand platform, expert networks and other emerging initiatives including start-ups, i-spaces, living labs, member states initiatives and incubators and connect with investors.

Critical to this ecosystem will be a strong connection between the AI PPP and the networks of Digital Innovation Hubs and comparable **national and regional initiatives** that will create and develop best-practice at a regional level. In this regard, strong connections to member states and policy makers at European, national and regional level are essential to federate efforts and investments.

Impact

This will **provide strong European leadership for AI** that ensures that European AI has a clear global voice that is rooted in its widespread deployment in sectors and regions across Europe. In addition, this will allow Europe to **develop a global AI position** that aligns with fundamental European values and delivers technology, products and services that maintain this goal by seeking to **align academic excellence** and innovation to the needs of both **industry and citizens**. It will lead to a healthy and **sustainable European AI ecosystem**. Formalised and effective cooperation's that are based on a clear understanding of the scope and focus, as well as the strength of each partner, serves as a basis for impact.

WA2: Skills and Acceptance

Objective

The AI PPP will take a broad perspective in understanding the AI skills challenge facing Europe. It aims to understand the demand and supply of AI skills in Europe, with consideration for the need for AI practitioners to have multi-disciplinary skills, and the necessity to connect non-technical disciplines that impact on AI and benefit from AI. It needs to ensure that appropriate curricula exist to support the skills demand and to recognise the need for life-long learning and vocational training. It needs to lead the debate to increase citizen, and organisational awareness of the AI skills need, and to increase the willingness of organisations to invest in skill building to close the skills gap. Finally, Europe needs to retain AI talents by making Europe an attractive place for AI workers.

Action

The partnership will work through its network to ensure that all stakeholders along the value chain, including citizens and users, have the understanding and skills to work with AI enabled systems, in the workplace, in the home and online. The AI PPP will take a holistic approach to the skills challenge: i) **Understanding**: Actively engage with industry to understand their skill requirements for AI and non AI workers. ii) **Promoting**: Create a career path identity for AI practitioners that spans

research, innovation, and industry. iii) **Engaging**: Stimulate citizen interest in STEM studies, starting from a young age. iv) **Improving**: Impactful R&I that aligns research excellence with industry's needs, ensuring the right environment, remuneration, and career options. v) **Inclusion**: The AI PPP will take action to ensure that diversity and inclusion are promoted throughout the skills pipeline.

Impact

The results of these actions will ensure that AI (and related) skills are widespread throughout Europe. These actions will increase the capacity of **AI education and vocational training** to support a **strong AI skills pipeline** at all educational levels to increase the supply of talent. The AI PPP will ensure that the successful adoption and deployment of AI is not limited by a lack of skills in the workforce by **retaining AI talent in Europe**. Finally, the partnership will propagate best practice on collaborative change and **increase the awareness of AI** within both public and private organisations and with citizens.

WA3: Innovation and market enablers

Objective

The objective in this work area is to ensure that the innovation environment in Europe is well founded by ensuring that the necessary assets and infrastructure exist for AI innovation and deployment; for example, data, IoT infrastructure, edge processing, HPC, test infrastructures etc. It is critical that innovators (SMEs, start-ups, etc.) can access this technical infrastructure and gain access to business expertise and finance that can help them react to new developments and opportunities and to enable scale-up.

Successful innovation is dependent on making connections; connections from market stakeholders to end users and to research and technical experts. These connections are bi-directional; just as end users need to understand the range of opportunities new technologies bring, innovators need to be aware of the opportunities that new business models could bring.

Action

The AI PPP will achieve these objectives by **aligning with end users** to obtain insights into business and market logic and by engaging with stakeholders along the AI innovation chain fostering cooperation and developing support for translation and deployment. The AI PPP will also carry out **monitoring of the innovation landscape** in Europe to assess progress and the health of AI innovation, adoption and deployment. It will also achieve impact by **promoting experimentation** and connection to existing and future AI infrastructure; Digital Innovation Hubs, on-demand platforms, data platforms, pilots etc. It will support and enable access to this infrastructure as well as to data and tools essential for AI innovation. It will also seek to **connect to financial institutions**, such as the EIB and EIF and VC funds, to create synergies and raise awareness of the AI investment opportunity in Europe.

Impact

These actions will **stimulate industrial investment** and private funding for AI in Europe and impact on the success of innovators translating research to market. They will contribute to creating a connected and **rich innovation ecosystem for AI** across Europe, contributing success by providing innovators with access to data and key innovation resources.

WA4: Guiding Standards and Regulation

Objectives

The AI PPP seeks to **create a level market** in Europe shaped around common worldwide standards and regulation and around common approaches to the certification and validation of AI-based products and services. This enables the smooth translation of innovation into the market by enabling innovators to more rapidly deploy products and services across and beyond Europe. It also enhances trust in AI by creating understandable guarantees for operation and behaviour. The impact of regulation and certification on product development and deployment is highly complex, especially when autonomous decision making or learning are involved. The AI PPP will **increase understanding of regulation** and recognises the need for **high-quality testing environments** to be available and accessible across all sectors and regions in Europe.

Action

The AI PPP will work to consolidate discussion around the development of common worldwide standards, especially around data, interoperability and trustworthiness, as these help to build supply chains and trust. It will engage in dialogue with regulators and end users to level out regulation and will seek to establish greater use of regulatory sandboxes and access to them across sectors and regions in Europe and beyond. Above all, it will promote the use of regulation to support innovation.

The AI PPP will promote the use and development of sector-specific AI guidelines and related impact assessments and will engage with businesses seeking to operationalise and pilot them. It will contribute to policy debates around the impact of AI and AI-driven value creation, including those around ethics, privacy and trustworthiness. Most importantly it will work with stakeholders in the AI Ecosystem infrastructure (Digital Innovation Hubs etc.) to identify areas where regulation is impacting on deployment and will **communicate to policymakers** where barriers to uptake and deployment are identified.

Impact

These actions will promote the awareness of regulation and standards within the AI Ecosystem, having a double impact: (i) making innovators more prepared for market entry, thereby accelerating time to market; (ii) raising awareness of regulators to the state and potential of technology, enabling the creation of the necessary, tailored regulation in an appropriate and timely manner. The wider use of AI guidelines and impact assessments will **help to build trust in AI**, both with stakeholders and citizens, while the wider use of standards will promote data flow and interoperability. The overall impact will be to **level the market for AI** in Europe and create scale through improved trust and the development of cross-sector supply chains.

WA5: Promoting Research Excellence

Objectives

A key objective of the AI PPP is to promote research excellence in the cross-sector technology enablers that are of strategic importance for trustworthy European AI. Europe needs to leverage its existing **scientific excellence in AI**, strengthen scientific cooperation, reduce fragmentation of research, and ensure access to world-class research infrastructure (HPC, testing infrastructure, European Network of AI Excellence Centre, etc.). Europe must enable and encourage AI researchers to work across disciplines. The AI PPP needs to ensure that research is **aligned with industry** needs and focus on solutions that boost deployment.

Action

The AI PPP will work with the academic and industrial communities to build actions to i) promote collaboration, networking and inter-disciplinarily, ii) promote European AI research excellence, and iii) align industry needs and research outcomes. These actions will be achieved by implementing the joint SRIDA collaboratively with the research and industrial stakeholder communities.

Impact

These actions will result in improved Academia-Industry collaborations that create a global AI leadership position for Europe on a foundation of academic excellence grounded with industrial relevance. It will improve the rate of technology transfer and adoption of AI **from the lab to real-world deployments**.

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OPEN COLLABORATION ON AI, DATA, AND ROBOTICS

In order to deliver the operational objectives of the AI PPP it is important to engage with a broad range of stakeholders. Each collaborative stakeholder brings a vital element to the functioning of the AI PPP and injects critical capability into the eco-system created around AI, data and robotics by the AI PPP.

The mobilisation of the European AI Ecosystem is one of the core objectives of the AI PPP. Its actions will bring together all the different communities and stakeholders; those already involved and those who will be affected by or stand to benefit from AI, data and robotics. An important focus of this is to support the horizontal components of the European AI Ecosystem to strengthen synergies between technologies, and to enable effective cross-sector value creation while seeking to explore constraints and address challenges.

Context of AI within the European Technical Ecosystem

The impact of AI is widely acknowledged and places AI, data and robotics as key drivers of the digital revolution. However, in order to extend their impact other technical competencies must be connected and integrated into AI applications, systems and infrastructure. AI, data and robotics therefore form part of a broader mix of technology that includes cybersecurity, connectivity, the Internet of Things, electronics, semi-conductors, computation, storage, software, and sytems design. Each of these areas in their turn utilise or contribute to AI, data and robotics.

Each of these technical areas has its own market development progression. Each is creating new markets and creating transformation within them and most have a European partnership to create coherence. As these market transformations progress and the complexity of deployable applications increases there is growing need to integrate a with a wider range of technologies. For example early markets may be satisfied by using of the shelf components and systems, but as the demand for greater performance and lower cost grows then the need to utilise more bespoke hardware, or more integrated communications, or dedicated analytics becomes the only way to expand deployment into new application areas. Initially each picks the “low hanging fruit” but to reach out into more complex application areas requires a more integrated technical approach. AI, data and robotics may only be needed at the most complex levels of application to bring greater levels of autonomy, understanding and control to complex multi-faceted systems for example in road transport, manufacturing logistics and healthcare diagnosis etc.

Achieving an effective deployment of AI, data and robotics within the digital economy can only be achieved when there is a coherent understanding of how these different technologies complement and interact with each other in the context of applications. This can be described as *cooperative intelligence*. For example the balance between edge and cloud based AI will depend on the criticality of timeliness in the task and this will have different approaches in different application areas, for example between industrial applications and autonomous vehicles. Other factors such as the level of autonomy and human interaction will also determine the balance of technologies needed.

The AI PPP forms part of a wider ecosystem of partnerships that cover all aspects of the technology application landscape in Europe. Many of these partnerships will rely on AI as a critical enabler to their own endeavours. Both horizontal (technology) and vertical (application) partnerships intersect around AI. The impact of AI in each of these partnerships will drive the need for connectivity between the AI PPP and each of them.

This section of the SRIDA sets out the nature of some of these collaborations and the partners that the AI PPP will seek to collaborate with. The nature of these collaborations will be governed by the identified synergies and benefits and are shaped by the Work Areas set out in the section "Implementing the AI PPP"

Horizontal Collaborations

As described above the core of this connectivity are collaborators that connect key supporting technologies. These are characterised as "horizontal collaborations" and reflect the need to work closely with organisations that champion co-technologies that are essential to the deployment of AI, data and robotics.

AI, data and robotics do not, in themselves, constitute complete systems of operation. In order to leverage the full potential of a completely digitised European Industry, an approach is needed which integrates a range of horizontal technologies.

The champions of these key co-technologies, critical to the deployment of AI, operate within existing associations and horizontal European partnerships and it is the development of these important strategic relationships that is set out in the following sections:

- **Cybersecurity with ECSO:** Active engagement with Cybersecurity is a critical enabler for AI so that organisations can reliably safeguard critical infrastructure, protect sensitive information and assure business continuity. The deployment of data, robotics and AI applications is not possible without a high level of trust, and an effective Cybersecurity regime underpins the development of that trust.
- **Smart networks and services with 5G IA:** Smart communications will be required to provide high speed and low latency networks to be delivered by 5G infrastructure, at the same time AI will be a key enabler for cost-effective communication networks.
- **Electronics, components, and systems with AENEAS, ARTEMIS-IA, and EPoSS:** The combination of Nano-electronics, Embedded Intelligence and Smart Systems Integration together with AI, Data and Robotics is central to continued digitalisation that will help industries to maintain their competitive edge.
- **High-performance computing with ETP4HPC:** High-Performance Computing (HPC) capabilities are needed by specific AI, data and robotics applications where faster decision-making is crucial and extremely complex data sets are involved, while AI capabilities improve the development and deployment of HPC solutions.
- **Internet of Things with AIOTI:** The alignment with Internet-of-Things technologies is needed to foster the seamless integration of IoT with data, robotics and AI technology.
- **Machine vision with EMVA:** Machine Vision with The European Machine Vision Association: Vision components can be seen as a major source to generate data and knowledge about the environment and are a basis for decision making and control in many application areas. Therefore, alignment with the European Machine Vision Association (EMVA) is of mutual benefit.

- **Software and systems with NESSI:** The creation of a new class of self-learning, self-optimising and self-adapting systems will create the need for novels ways of software and system development. Software engineering will need to be “re-engineering” concerning software design and architecture, data lifecycles, quality assurance, and deployment on dedicated hardware.

The following sections detail the key horizontal collaborations identified to date and sets out the rational for cooperation and alignment.

Cybersecurity with ECSO

The European Cyber Security Organisation (ECSO) ASBL is a fully self-financed non-for-profit organisation under the Belgian law, established in June 2016.

ECSO represents the contractual counterpart to the European Commission for the implementation of the Cyber Security contractual Public-Private Partnership (cPPP). ECSO is an umbrella organisation: it's members include a wide variety of stakeholders representing the public and private sectors, as well as European Member State's local, regional and national administrations. The main objective of ECSO is to support all types of initiatives or projects that aim to develop, promote, encourage European cybersecurity, well beyond the initial objectives of the cPPP focussed on R&I issues. ECSO's particular aim is to foster and protect from cyber threats the growth of the European Digital Single Market, to develop the cybersecurity market in Europe and of a competitive European cybersecurity and ICT industrial base. ECSO gathers and stimulates cooperation of the European Community. It also aims to support the development and implementation of European cybersecurity solutions for the critical steps of trusted supply chains, in critical applications, in particular where Europe is a leader. ECSO sees Data, Robotics and AI as strategic elements for the growth of Europe and as such considers the protection of their use as well as the dangers of their misuse as one of the most important priorities of our Community.

Why is the cooperation needed?

Cybersecurity and Artificial Intelligence naturally complement each other and are closely related. Robotics and Artificial Intelligence could be used, and could even be more efficient in performing automated and sophisticated attacks to a system rather than protecting it, creating novel and extended security threats. At the same time AI, data and robotics can be used to significantly improve cybersecurity technologies as well as parts of the processes enabling cyber and physical security, for instance by providing automatic responses to security incidents or even the deployment of security controls in the case of vulnerabilities to minimise risk exposure. Given the increasing number and types of AI systems, cybersecurity methods will play a key role in ensuring technical robustness, resiliency, and dependability. The value of AI relies on high quality data with good provenance; thus, the impact of falsified data and trust in data is a central consideration. It is therefore important to define concepts of measurable trust, reputation- and evidence-based trust, computational models of trust, assurance models, fake information and deep fake. AI-driven systems face all known cybersecurity challenges, such that data should be secured at rest and in motion. In addition to the challenges already highlighted, it is vital to consider the interplay between safety and security, which will be particularly important in robotics. AI-driven systems should comply with existing regulations and legislations in a demonstrable way, for example through a continuous assessment to demonstrate that fundamental rights such as privacy are appropriately addressed. Some of them need to be auditable, though court-capable forensics techniques.

None of the disciplines can solve all these challenges alone. The collaboration is needed and will be built upon the already ongoing joint activities between ECSO with BDVA and euRobotics.

Smart networks and services with 5G IA

The 5G Infrastructure Association (5G IA)[23] represents the private side in the European H2020 5G Public-Private Partnership (5G PPP). This provides the business dimension on top of the technical work delivered by European research to facilitate faster uptake of results and point the way to disruptive research directions. The primary objective of the 5G IA is to promote and support European leadership for the development, deployment and evolution of 5G and to ensure a strong European voice on 5G around the world. In February 2019 the 5G IA published a Position Paper for a European Partnership on Smart Networks and Services under Horizon Europe aiming at developing the essential digital infrastructure for the Human Centric Internet, enabling the development of European strategic value chains for the 'Industrial Internet of Things' and for 'Connected, Automated and Electric Vehicles"[24], among other key sectors.

Why is cooperation needed?

Smart Networks and Services is a critical cross-sectorial infrastructure and research enabler for artificial intelligence, big data, next-generation cooperative robots, high-performance computing and cybersecurity. Joint research between Smart Networks and Services, IoT, AI, Data and Robotics assets will create more value, increased sector knowledge, and ultimately more ground for new sector applications and services. Looking at Smart Networks as a vertical market for AI opens joint scientific challenges in trustworthy hybrid decision making. Two key areas where such decisions will be impactful are i) decentralised and automated network management and optimisation, and ii) intelligent spectrum management. Research on those areas will help to lower barriers in verticals investing in 5G and future communication technologies.

Synergies can be leveraged in different areas; Smart communication is a key technology for AI, while AI is a crucial technology for future cost-effective communication systems and networks. Systems will increasingly be based on distributed Artificial Intelligence (AI) and Machine Learning (ML). Multiservice and Edge Computing will allow the storage and processing of data locally at the edges of the network to provide fast reaction and efficient use of network resources. Robust and reliable communications are needed as a critical enabler for trustworthy AI to protect the integrity and privacy of data across technologies, borders, and value chains. Finally, standards in 5G have developed very soundly, while in AI, Data and Robotics the landscape is much more fragmented. Both partnerships see benefit in working together in some verticals (e.g. Automotive, Industry 4.0), sharing information about standardisation bodies they are involved in, and pursuing industry consensus.

23 https://5g-ia.eu/

24 Inception impact assessment Smart Networks and Services PPP (https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2019-4972300_en)

Electronics, components, and systems with AENEAS, ARTEMIS-IA, and EPoSS

Key Digital Technologies (KDT)[25] is the proposed European Partnership under the next Multi-annual Financial Framework of the European Union to support the development of European strategic value chains for microelectronics and the industrial 'internet of things', as identified by the Strategic Forum for Important Projects of Common European Interest (IPCEIs). The proposed KDT partnership will build on the experience gained from the Joint Undertaking on Electronics Components and Systems for European leadership (ECSEL) and, satisfy the more demanding societal, economic and technological impact criteria of Horizon Europe.

The ECSEL Joint Undertaking - the Public-Private Partnership for Electronic Components and Systems – funds Research, Development and Innovation projects for world-class expertise in these key enabling technologies, essential for Europe's competitive leadership in the era of the digital economy. The members of ECSEL JU are the three associations AENEAS[26], ARTEMIS-IA[27], EPoSS[28] and the European Union (through the European Commission) and 26 Member States and 4 Associated Countries to H2020.

Why is cooperation needed?

The availability of the key digital technologies is a central lever for the cross-sectorial deployment of AI, data and robotics. By combining Nano-electronics, Embedded Intelligence and Smart System Integration, AI, data and robotics methods, paradigms and assets, substantial new resources (infrastructure, knowledge and R&I) can be developed that will help industries to maintain their competitive edge. Thus, advancing key digital technologies and their use will enhance novel technologies such as AI, data and robotics. Research into electronics components and systems and relevant aspects of software technologies and photonics are featuring increasingly in the digital transformation of the economy and society. By increasing its digitalisation efforts Europe will facilitate access to a wide range of data sources that can then be used as input for developing a wide range of AI applications. At the same time, emerging AI value opportunities will stimulate the adoption of key digital technologies.

The collaboration between the KDT and AI partnerships will establish the basis for leveraging synergies at different levels: the development of innovative cognitive functions for smart systems can build upon research in sensing, measurement and perception; while the expertise needed to assemble different technologies to build products and services can be leveraged for developing innovative systems, methodologies and hardware for AI systems. In addition safety, security and reliability, as well as the embedding of AI applications into the edge, are central requirements for both European Partnerships.

25 Key Digital Technologies Inception Impact assessment, https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2019-4972315_en

26 **AENEAS** is an Association, established in 2006, providing unparalleled networking opportunities, policy influence & supported access to funding to all types of R&D&I participants in the field of micro and nanoelectronics enabled components and systems. See https://aeneas-office.org

27 **ARTEMIS Industry Association** strives for a leading position of Europe in Embedded Intelligence. The multidisciplinary nature of the membership provides an excellent network for the exchange of technology ideas, cross-domain fertilisation, as well as for large innovation initiatives. See https://artemis-ia.eu

28 **EPoSS**, the European Technology Platform on Smart Systems Integration, is an industry-driven policy initiative, defining R&D and innovation needs as well as policy requirements related to Smart Systems Integration and integrated Micro- and Nanosystems. See www.smart-systems-integration.org

High-performance computing with ETP4HPC

ETP4HPC – the European Technology Platform (ETP) for High-Performance Computing (HPC) - is a private, industry-led and non-profit association with the mission to foster European HPC technology-related research, development and innovation in order to maximise the economic and societal benefit of HPC for European science, industry and citizens. Their primary focus is to propose research priorities and work programme contents in the area of HPC technology and usage.

The EuroHPC Joint Undertaking (EuroHPC JU) is a joint initiative between the European Commission and European member states to develop a World Class Supercomputing Ecosystem in Europe. The Joint Undertaking will pool EU and national resources in High-Performance Computing, with an initial 1 billion Euro programme, with the aim of:

- Acquiring and providing a world-class supercomputing and data infrastructure for Europe's scientific, industrial and public users, starting with petascale and pre-exascale (precursors to exascale) systems in 2020.

- Supporting an ambitious research and innovation agenda to develop and maintain in the EU a world-class High-Performance Computing ecosystem, exascale and beyond, covering all scientific and industrial value chain segments, from low-power processor, I/O, network and middleware technologies, algorithms and programming environments, applications and systems, know-how and skills development for the next generation supercomputing era.

Why is cooperation needed?

The convergence of HPC and Artificial Intelligence (AI) is critical for applications that rely on Big Data and High-Performance Data Analytics (HPDA)[29].

AI and HPC are by their nature synergetic. On one side, today, both deployment fields take advantage of heterogeneous system architectures based on heavy use of accelerators. Large Deep Learning workloads perform best on these system structures as do large scale simulation codes for both scientific and industrial use cases. On the other side AI and HPC together with Data Analytics are elements of a "digital continuum" workflow based on an entire infrastructure ecosystem stretching from data centres to cloud, fog and edge computing.

In some sectors, AI, Data and Robotics applications are expected to move towards more compute-intensive algorithms to reach deeper insights across descriptive (explaining what is happening), diagnostics (explaining why it happen), prognostics (predicting what can happen) and prescriptive (proactive handling) analysis. The adoption of specific HPC-type capabilities by AI, data and robotics technologies is likely to be of assistance where faster decision-making is crucial and extremely complex data sets are involved – i.e. extreme data analytics combining AI and HPC in earthquake prediction and the reconfiguration of complex neural networks. From humble beginnings (such as finding hidden and very intricate patterns in simulated and observed data), the first generation of combined applications is now emerging. "AI for HPC" where AI capabilities improve the development and deployment of HPC solutions. AI systems will have necessarily to meet safety, trustworthiness, reliability and dependability requirements. AI for HPC will affect all HPC tools, processes, methodologies, architectures, infrastructures and standards. Power consumption will also be a significant challenge.

29 ETP4HPC and BDVA are private members of the EuroHPC JU, and both associations have representatives in the EuroHPC Research and Innovation Advisory Group (RIAG). First common publication: http://www.bdva.eu/sites/default/files/bigdata_and_hpc_FINAL_16Nov18.pdf

Internet of Things with AIOTI

AIOTI is the multi-stakeholder platform for stimulating IoT Innovation in Europe, bringing together small and large companies, start-ups and scale-ups, academia, policymakers and end-users and representatives of society in an end-to-end approach. The mission of the Alliance of Internet of Things Innovation (AIOTI) is to foster the European IoT market uptake and position by developing ecosystems across vertical silos, contributing to the direction of H2020 large-scale pilots, gathering evidence on market obstacles for IoT deployment in the Digital Single Market context, championing the EU in spearheading IoT initiatives, and mapping and bridging global, EU and Members States' IoT innovation and standardisation activities. AIOTI working groups cover various vertical markets from Smart Farming to Smart Manufacturing and Smart Cities, and specific horizontal topics on standardisation, policy, research and innovation ecosystems. The AIOTI was launched by the European Commission in 2015 as an informal group and established as a legal entity in 2016. It is a significant cross-domain European IoT innovation activity.

Why is cooperation needed?

Internet of Things (IoT) technology, which enables the connection of any smart device or object, will have a profound impact on many sectors in the European economy that will trigger significant growth in the amount of data. According to Gartner[30], there will be over 14 billion connected devices by the end of 2019, and over 25 billion by the end of 2021. This growth in data will lead to future market expansion in the IoT business; for instance, the global IoT market was worth over $150 billion in 2018 and is expected to exceed $1.5 trillion by 2025[31]. Fostering this future market growth requires the seamless integration of IoT technology (such as sensor integration, field data collection, Cloud, edge and fog computing) with AI, Data and Robotics technology. By jointly building IoT-enabled Data Marketplaces along four well-defined maturity stages[32] the horizontal integration of IoT and AI, data, robotics technology can be guided and fostered.

30 https://www.gartner.com/en/newsroom/press-releases/2018-11-07-gartner-identifies-top-10-strategic-iot-technologies-and-trends

31 https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/

32 European IoT challenges and opportunities 2019-2024, An IoT Enabled Future. Alliance for Internet fo Things, July 2019.

Machine vision with EMVA

The European Machine Vision Association (EMVA) is a non-for-profit and non-commercial association representing the Machine Vision industry in Europe. The association has been founded in 2003 in Barcelona by industry representatives from all over Europe as a network to promote the development and use of machine vision technology.

The EMVA is open for all types of organisations having a stake in machine vision, computer vision, embedded vision or imaging technologies: manufacturers, system and machine builders, integrators, distributors, consultancies, trade press, research organizations and academia. All members – as the 100% owners of the association – benefit from the networking, cooperation and the numerous and diverse activities of the EMVA.

Why is cooperation needed?

Vision technology is part of many smart devices or objects, and has a significant impact on many sectors in the European economy, including autonomous cars, transportation in general, agri-food, healthcare, in manufacturing, maintenance and inspection, quality control, the security sector, smart cities, human machine interaction and many others. Vision components can be seen as a major source to generate data and knowledge about the environment and are a basis for decision making and control, this includes image or video acquisition technologies, such as 3D data generation, spectral imaging, x-ray, or controlled illumination. 99% of all captured raw data is pixels, 75% of all data entering the human brain is vision data. Consequently, 49% of all AI patents relate to computer vision.

A seamless integration of vision technology in applications is a must for the development of such systems, where especially for mobile systems, energy consumption and communication structures are important factors to be considered.

Europe is well known to be the world leader in the development and deployment of vision technologies, with a particularly strong presence in the industrial sector. Europe has led the world, both in the development of hardware and software over the past 30 years. This trend continues, but the rapid development of vision based AI technology both in China and North America poses risks to technology leadership as well as opportunities, for example in the development of worldwide standards to enable clear guidance to implementation and adoption of vision technologies.

The EMVA provides a strong eco-system of manufacturers, end users, and research institutes, underpinned by a very active standards development programme and various other activities. The opportunity exists to leverage this network of members to help promote the wider vision of the AI PPP, increase participation and cross-sector networking, and ultimately align the strategies of European vision technology players with the AI PPP agenda. At the same time, many of the companies operating in the broader AI eco-system share suppliers, customers, end-users, and sources of talented employees, as well as technical approaches to problem solving which leads to a natural cooperation opportunity.

Software and systems with NESSI

NESSI, the Networked Software and Services Initiative, is the European Technology Platform, for the digital information society and an economy powered by software, services and data. The main aim of NESSI is to promote research, development and innovation in the field of software, cloud/edge/fog computing, data and digital services in order to strengthen the competitiveness of the European industry in this field and represent industry and other organisations active in this field. NESSI is registered as an international not-for-profit association under Belgian law. NESSI has a strong background of shaping European research on software systems and methodologies, as well as software deployment on virtualised hardware, such as cloud and fog computing. NESSI thereby provides complementary expertise for shaping the AI PPP SRIDA, in particular contributing to the cross-sectorial AI technology enablers "Systems, Methodologies and Hardware".

Why is cooperation needed?

The NESSI view is that without software, there is no AI[33]. It is important to recognise both, the challenges of AI software and what AI can bring to software. Embedding AI algorithms into complex software systems is fundamental to delivering AI-based innovations and thus for the achievement of the vision for AI. AI will empower a new class of self-learning, self-optimising and self-adapting systems, which calls for novel ways of developing software and systems. The governance of AI-based systems and suitable software architectures and software engineering methodologies for AI are challenges which need to be explicitly addressed.

Addressing these challenges requires "re-engineering" software engineering concerning software design and architecture, software and data lifecycles, quality assurance, as well as deployment on dedicated hardware. As an example, AI-based self-adapting software systems help master the complexity, dynamicity and uncertainty entailed in developing software systems. By learning at run-time, they can handle situations that cannot be anticipated at design time, due to incomplete knowledge and uncertainty about the system environment. However, such learning at run-time requires novel ways of developing, debugging and testing these systems; e.g., determining causality and liability for autonomous actions and decisions.

33 NESSI Whitepaper, "Software and Artificial Intelligence", 2019, http://www.nessi.eu/Files/Private/NESSI%20-%20Software%20and%20AI%20-%20issue%201.pdf

Engagement with European Funded Projects

A vital part of the European AI Eco-system are the projects funded through the European Commission Framework programmes. These public investments stimulate interaction and exchange within the Eco-system boosting the adoption of AI and the development of excellence. However their success is pivotal on generating market impact that both stimulates private investment and generates new market opportunities. It is not sufficient for these investments to solely deliver greater academic connectivity and exchange. They must deliver real economic impact and novel technology that creates step changes in AI, data and robotics market places. They must also focus on cross-fertilising opportunity between multiple vertical sectors and in the horizontal infrastructure, service and component markets.

The AI PPP will engage strongly with these major public AI infrastructure investments and work closely with the consortia that operate and develop them to ensure that the impacts are maximised. Both associations, BDVA and euRobotics, will continue to actively stimulate connections between their members and these infrastructures and will guide private investment to boost Europe's overall private spend in AI to reach Commission targets.

To achieve this these publicly funded infrastructures, such as the on-demand platform, must be open, secure, valuable and effective assets managed for the whole eco-system and to the benefit of both academics and industrial companies both large and small. Well-founded accessibility mechanisms and low barriers to entry are essential so that start-ups and SMEs can rapidly bootstrap their AI skills and deployment. This should be aided through the networks of AI-based Digital Innovation Hub networks such as those set up in AI, Big Data and Robotics, and through future networks of Digital Innovation Hubs in each region. It must leverage the emerging European Data Space to enable new data value chain opportunities, building upon existing initiatives and investments (data platforms, i-spaces, big data innovation hubs) for AI Innovation.

Equally critical is open access to research stimulated through the AI Centres of Excellence Networks. Success for AI in Europe is pivoted on the rapid transfer of knowledge and skills from academia to industry and the effective propagation of industrial challenges back into academia. The global race to achieve high levels of AI deployment and the consequent economic gain will depend heavily on a well-founded and skilled workforce and on accessible, comprehensible tools that facilitate rapid uptake. These are driven by a coordinated and integrated AI research community that is jointly committed to developing excellence not only in AI but in collaboration; collaboration both with each other and with industry.

The following initial actions are envisaged:

1. Engage directly with the consortia managing the public AI infrastructure to work on strategic direction and issues, and with the Coordination and Support Actions that surround each AI asset.
2. Disseminate awareness of these resources within the broader eco-system and with partners in the AI PPP.
3. To independently assess and strategically align the impact of the public AI infrastructure on the eco-system and its industrial uptake.

Engagement with AI Research Communities

To understand the fertile ground European research has to offer, it is important to understand the AI expertise which is available and leading in Europe. Europe excels in various areas of AI both in the underpinning theory and in its application. Europe has a long history of strength in both data and robotics, in the digital and physical aspects of AI and in the underlying paradigms. The interplay of AI, Data and Robotics with 5G with IoT, with HPC is embedded within European AI expertise. Europe has pioneered trustworthy and physically safe AI, Data and Robotics where autonomous systems operate synergistically with humans. The future of nature of AI and the development of its capabilities rests with the European AI research communities and it is of vital importance that the AI PPP has a strong and effective working relationship with all areas of AI research, including ethical, legal, social and economic (ELSE) research so that it can build strategy and direction on a strong evidence base.

AI, Data and Robotics are still at an early stage of development and adoption. There are key advances and step change discoveries still to be made. The innovation pipeline can only be fed by strong research excellence and Europe is in a unique position globally to coordinate and shape a programme of public investment that can maximise return; a return on ideas, novelty and innovation in AI. Critical to success will be the collation of pan-European and member state funding.

Europe has built an impressive network of individual AI labs and centres of excellence. It is critical that, in the process of extracting the economic advantage from this investment, proper attention continues to be paid to fundamental research and that both public and private investments are channelled to support novel and challenging ideas driven research.

However there will never be sufficient funding to develop every idea. It is essential that careful prioritisation is carried out so that ideas with promise are funded first, however leaving space for blue-sky disruptive ideas as proposed by the research community. It is equally important, that these priorities are reviewed and challenged on a regular basis. Consensus building in the academic community is a difficult process but one that both euRobotics and BDVA have significant experience achieving. This consensus building process will include the research and industrial communities. The development of long-term research roadmaps and their use to drive strategic orientation is a critical function of the AI PPP as it has been for both euRobotics and BDVA in their respective cPPPs. To achieve success AI researchers will need to engage and collaborate in the AI PPP that will offer them advantages in doing so.

The following initial actions are envisaged:

1. To create consensus building processes within the European AI research community.
2. To establish a long term view of AI data and robotics for Europe based on strengths, expertise and challenges.
3. To guide the orientation of public investment in fundamental AI research to ensure Europe's strong strategic and technical position is maintained including the consideration of significant blue-sky research element.

Engagement with EC Strategy

The rapid emergence of AI has awakened the need for Europe and its member states to examine their strategy and policy towards its impact. From this has come a wide range of guidelines and official strategies that must be taken into account by the AI PPP if it is to work across the whole European AI eco-system encompassing industry, member states, associations and academics.

There are many diverse perspectives on AI, data and robotics because of the wide spread of its potential impact and the fact that it must be treated as a Socio-Technical system which has ethical and societal dimensions. The AI PPP must work to channel these different viewpoints so that deployment is acceptable and effective; acceptable to citizens and business and justifiable in the applications it is deployed in.

Work in ongoing within the AI Alliance and the AI High Level Group to set out guidelines and strategic directions that respect multiple and diverse views on AI and the AI PPP seeks to take their recommendations on-board as they are finalised and tested. Critical to this will be developing AI deployment strategies that can deliver against expectations that AI can be made trustworthy and comprehensible while at the same time making commercial sense.

Critical to EC policy on AI is alignment with the individual actions of the member states. Alignment that creates a common AI market place across Europe, Alignment on standards of operation and ethical governance, alignment in public investment in AI infrastructures and research.

The following initial actions are envisaged:

1. To seek ways to implement and align the diverse strategies around European AI to generate a well-founded market for AI data and robotics in Europe.
2. To build long term partnerships and alliances with non-technical associations and bodies that are impacted by AI, data and robotics or have an interest in its deployment.
3. To examine and monitor the wider viewpoint of communities and special interest groups on the deployment of AI, data and robotics in Europe with the objective of creating an effective AI, data and robotics market in Europe.

Have your Say: Get Involved in the Open Consultation

The objective of this Consultation Release SRIDA is to bring together the stakeholders from the European AI Innovation Ecosystem to achieve a consensus on the way forward in advancing AI in Europe developing strong foundations for a European Public-Private Partnership on AI.

We are at the beginning of this journey, and extend an open and welcome invitation to all to provide their views, to given feedback, join us in improving it and making it this SRIDA a reality.

Interested parties are invited to get in contact with us joining the upcoming BDVA and euRobotics events and to reach the Partnership Coordination Group at joining-forces@ai-ppp.eu to have their say in the next release.

BDV
BIG DATA VALUE
ASSOCIATION

eu ROBOTICS

BACKGROUND AND CONTEXT

The European Commission's Coordinated Plan on Artificial Intelligence[34] calls for the development of an industrially led AI Partnership triggered by the Big Data Value Association (BDVA) and the European Robotics Association (euRobotics) through the joint action of their respective cPPPs. In December 2018 at the Vienna ICT Conference BDVA and euRobotics signed a Memorandum of Understanding and committed to developing a new AI partnership[35] [36]. *This partnership recognises that the full value of AI comes when it unifies information and motion, digital and physical, data and robotics*. This vision paper is the first expression of this new partnership for AI in Europe, an industry-driven partnership between robotics and data[37].

The partnership is built on two well-established associations representing over 400 European organisations from Industry and Research[38]. Each recognise the mutual value in building a new partnership. Both are industry led and focused on achieving impact in the market, their scope covers mutually complementary AI technologies and they understand the need to stimulate its uptake across all sectors and between industries in order to maximise the gain for Europe. The Big Data Value Association (BDVA) promotes the development of the Innovation Ecosystem to enable the data-driven digital transformation in Europe delivering maximum economic and societal benefit, and, achieving and sustaining Europe's leadership on Big Data Value creation and Artificial Intelligence. The European robotics association (euRobotics) promotes robotics uptake in Europe by joining together industrial and academic organisations and engaging directly with end users in exploring and developing the opportunity robotics brings to industrial and service markets. Both associations understand that each brings the other a significant advantage in terms of impact.

Each association has a cPPP agreement with the European Commission under Horizon 2020 and works with the Commission to define strategy and work programmes, within their respective areas, supported by their individual Strategic Agenda documents. Both have been actively engaged in shaping the strategic discussion around AI in Europe and have identified key challenges for AI. The opportunity to develop a new partnership while continuing to serve their existing members is seen by both associations as an important next step that can accelerate the competitiveness of European industry.

34 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic, and Social Committee and the Committee of the Regions - Coordinated Plan on Artificial Intelligence (COM(2018) 795 final), 7th December, 2018.

35 Data-Driven Artificial Intelligence For European Economic Competitiveness And Societal Progress, BDVA Position Statement, November 2018.

36 euRobotics Vision Paper on AI

37 **"Artificial Intelligence: Public-Private Partnerships join forces to boost AI progress in Europe"** https://ec.europa.eu/digital-single-market/en/news/artificial-intelligence-public-private-partnerships-join-forces-boost-ai-progress-europe

38 The combined membership of both associations represent Large Industry, SMEs, Research/Academic and Public and Non-for-profit. BDVA membership comprises of 28% SMEs, 16% Large Enterprise, 50% Research with the remainder public entities or non-profit. euRobotics membership comprises 19% SMEs, 13% Large Enterprises, 62% Research, and 6% associated members, such as regions or non-profit organisations.

About BDVA

The Big Data Value Association (BDVA) is an industry-driven international not–for-profit organisation with 200 members all over Europe and a well-balanced composition of large, small, and medium-sized industries as well as research and user organizations. BDVA is the private counterpart to the European Commission to implement the Big Data Value PPP program. BDVA and the Big Data Value PPP pursue a common shared vision of positioning Europe as the world leader in the creation of Big Data Value.

The mission of the BDVA is to develop the Innovation Ecosystem that will enable the data-driven digital transformation in Europe delivering maximum economic and societal benefit, and, achieving and sustaining Europe's leadership on Big Data Value creation and Artificial Intelligence.

BDVA enables existing regional multi-partner cooperation, to collaborate at European level through the provision of tools and know-how to support the co-creation, development and experimentation of pan-European data-driven applications and services, and know-how exchange.

About euRobotics

euRobotics is a Brussels-based international non-profit association that works to boost European robotics research, development and innovation and to foster a positive perception of robotics. The 250-plus members are research organisations, including universities, and commercial companies. euRobotics aims to strengthen the competitiveness of, and collaboration between, manufacturers, providers and users of robotics systems and services, and to ensure that robotics is adopted widely for professional and private use.

euRobotics represents the private side of SPARC, the public-private partnership with the European Union to maintain and extend Europe's leadership in civilian robotics. Its aim is to strategically position European robotics in the world, thereby securing major benefits for Europe's economy and society at large. SPARC leads the driving strategy behind the largest civilian robotics research and innovation programme in the world, with €700 million in funding from the European Commission from 2014 to 2020 and triple that from European industry, to yield a total investment of €2.8 billion.

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Members of the Board of Directors of BDVA (http://bdva.eu/board-members) and euRobotics (https://www.eu-robotics.net/eurobotics/about/board-of-directors)

We are very grateful to the 200+ participants at the 6 workshops by BDVA and euRobotics held in Feb-May 2019:

- BDVA workshop on February 27th (BDVA members and BDV PPP projects)
- Joint workshop on March 20th in Bucharest (public at ERF2019)
- euRobotics workshop on April 11th in Brussels (with BDVA participation)
- BDVA workshop on April 30th in Brussels (with euRobotics participation)
- euRobotics workshop on May 8th in Brussels (with BDVA participation)
- BDVA workshop on May 16th in Brussels (with euRobotics participation)

Additional workshops/events that contributed to the second version:

- "Joining forces to boost AI adoption in Europe" event, organised by BDVA and euRobotics on June 6th 2019 in Brussels.
- BDV PPP Summit on June 26th - 28th in Riga[39]
- Bilateral online meetings with all the addressed communities

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- Representatives from CLAIRE, EurAI, ELLIS and Humane AI

Note:

This document should be referenced as follows: Zillner, S., Bisset, D., García Robles, A., Hahn, T., Lafrenz, R., Liepert, B., and Curry, E. (eds) (2019) *"Strategic Research, Innovation and Deployment Agenda for an AI PPP: A focal point for collaboration on Artificial Intelligence, Data and Robotics. Second Consultation Release."* September 2019, Brussels. BDVA – euRobotics

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NOTES

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