

GOBIERNO  
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SPANISH RDI STRATEGY  
IN ARTIFICIAL  
INTELLIGENCE

# SPANISH RDI STRATEGY IN ARTIFICIAL INTELLIGENCE

Ministry of Science, Innovation and Universities, 2019



*General catalogue of official publications*

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The authorship of this publication corresponds to the General Secretariat of Scientific Policy Coordination of the Ministry of Science, Innovation and Universities and to the Artificial Intelligence Task Force (GTIA, Grupo de Trabajo de Inteligencia Artificial).



**Edited by:** General Technical Secretariat of the Ministry of Science, Innovation and Universities

**Design and layout:** FECYT – Fundación Española para la Ciencia y Tecnología.



**e-NIPO:** 692-19-006-2

**Cover photo:** Adobe Stock

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## PROLOGUE BY PEDRO DUQUE

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### Minister for Science, Innovation and Universities of the Spanish Government

In 1950, Alan Turing published his article "Computing Machinery and Intelligence", in which he established the test that now bears his name. He said that if a machine behaves in all respects as if it were intelligent, then it must be intelligent. More than 60 years later, Artificial Intelligence is a set of increasingly advanced technologies that are already changing our lives and will do so with much greater impact in the future.

We are still far from the accomplishment of making machines behave in all aspects as if they were intelligent, but the availability of technologies based on Artificial Intelligence, especially the growing capacity of machines to store and evaluate huge amounts of information and draw conclusions from them, announces that the time has come for us to be prepared. These technologies are already one of the main growth factors; their products, services and systems are already in the homes and on the streets and their global economic impact is estimated at 14 trillion Euros for the year 2030.

It seems increasingly clear that AI will lead to a new social and economic reality. It is already doing so. China and the United States are making great strides in this field, while the European Union is working for Member States to dedicate efforts to AI; so it has set 2019 as the deadline for each country to develop its National Strategy.

The current **Spanish Strategy for RDI in Artificial Intelligence** is configured as the core element of a key R+D vision of its own for the development of the European framework called "Coordinated AI Plan", approved at the end of 2018. In addition, it is aligned with the efforts aimed at meeting the sustainable development objectives set out in the Action Plan for the Implementation of Agenda 2030 in Spain.

This Strategy is the result of the work carried out over the last few months by a group of experts in the different AI technologies. It establishes **six priorities**, the main objective of which is to make the tools aimed at promoting RDI more effective and to indicate how and where the different technologies can help our country's growth. Customized medicine, the digitalization of services aimed at tourism, the challenges posed by cyber-security or an interoperable and digital public administration are some of the challenges that Artificial Intelligence will help to solve in Spain.

The Strategy is also born with seven **recommendations** that seek to align normative, structural and organizational adaptations to the achievements made in Artificial Intelligence in the different public policies. This is so to such an extent that the Government's Delegate Committee for Scientific and Technical Policy and Innovation, chaired by the Vice President and attended by 11 ministers, agreed in December 2018 to create an inter-ministerial working group to respond to this strategic axis of Spanish society in the 21st century. This Strategy will therefore be the embryo of the future **National Strategy for Artificial Intelligence**, which will allow us to coordinate and align State investments and policies, improving synergies and facilitating public and private investments aimed at encouraging the use of these technologies in our society and economy.

Pedro Duque  
Minister for Science, Innovation and Universities



## THANKS FROM THE SECRETARY-GENERAL FOR SCIENCE POLICY COORDINATION

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Many people have participated in the preparation of this Strategy, among whom we would like to give special recognition to those who formed the Artificial Intelligence Working Group led by Research Professor Ramón López de Mántaras, National Research Award 2018 of the Artificial Intelligence *Consejo Superior de Investigaciones Científicas* (Research Institute of the Spanish National Research Council). Among its members, this group has had Josep Maria Martorell from the Barcelona Supercomputing Center-National Supercomputing Center; Francisco Herrera and Oscar Cordon from the University of Granada; Josep Lladós from the *Centre de Visió per Computador* at the Autonomous University of Barcelona; Pedro Larrañaga and Asunción Gómez Pérez from the Polytechnic University of Madrid; Ulises Cortés of the Polytechnic University of Catalonia; Amparo Alonso Betanzos as President of the Spanish Association of Artificial Intelligence and professor at the University of La Coruña; Joseba Laka and Javier del Ser of Tecnalia; and members of the Cabinets of this General Secretariat of Scientific Policy Coordination, Petra Fernández, Elisa Robles and David González; of the State Secretariat of Universities, Research, Development and Innovation, Francisco Salvador and Gonzalo Remiro of the Cabinet of the Minister of Science, Innovation and Universities.

This group has managed to show the global transforming character of these technologies in this Strategy, has identified key points where the different levels of public administration should focus their efforts not only on the financing and improvement of the tools that allow the development of AI technology and its uses, but also on how and where the interests should be aligned in Spain, in Europe and at a global level; the identification of strategic areas, which through the resources and services that AI can offer, will be essential for the social and economic development of Spain; and the degree of maturity in the implementation of AI technologies. All of this is essential when it comes to developing a Spain in this new digitalized era.

Its work has made it possible to clearly see the areas of IA interlocution in different areas of the Public Administrations, which means that the work reflected in the present Spanish Strategy for RDI in Artificial Intelligence will be essential in the drafting of the National Artificial Intelligence Strategy for which the Artificial Intelligence Working Group created in the Delegate Commission for Science, Technology and Innovation is responsible and which is beginning its work in February 2019.

Finally, our thanks to the opinions and comments expressed by the following people: Federico Buyolo, Director General of the High Commissioner Agenda 2030; Agustina Piedrabuena, Emilio García and Juan Santaella of the State Secretariat for Digital Advancement of the Ministry of Economy and Business and Enric Banda as President of the Advisory Council for Science, Technology and Innovation.

Rafael Rodrigo  
Secretary General for Science Policy Coordination

## **ON THE MINISTRY OF SCIENCE**

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The Ministry of Science, Innovation and Universities is the department of the General State Administration in charge of executing the Government's policy on universities, scientific research, technological development and innovation in all sectors. The Ministry assumes the direction of international relations in this area and the Spanish representation in programmes, forums and international and European Union organizations within its competence.

## **ON THE SECRETARIAT-GENERAL FOR SCIENCE POLICY COORDINATION**

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The General Secretariat for Science Policy Coordination (Spanish acronym: SGPC), a unit that reports directly to the Ministry of Science, Innovation and Universities (Spanish acronym MCIU), has the essential function with respect to this RDI Strategy in Artificial Intelligence (AI) of giving impetus to and coordinating activities to promote AI, designing strategic planning and facilitating international cooperation in RDI, in addition to coordinating the position of the MCIU with other ministerial departments as well as the Spanish participation in the elaboration, design and monitoring of European policies in AI.

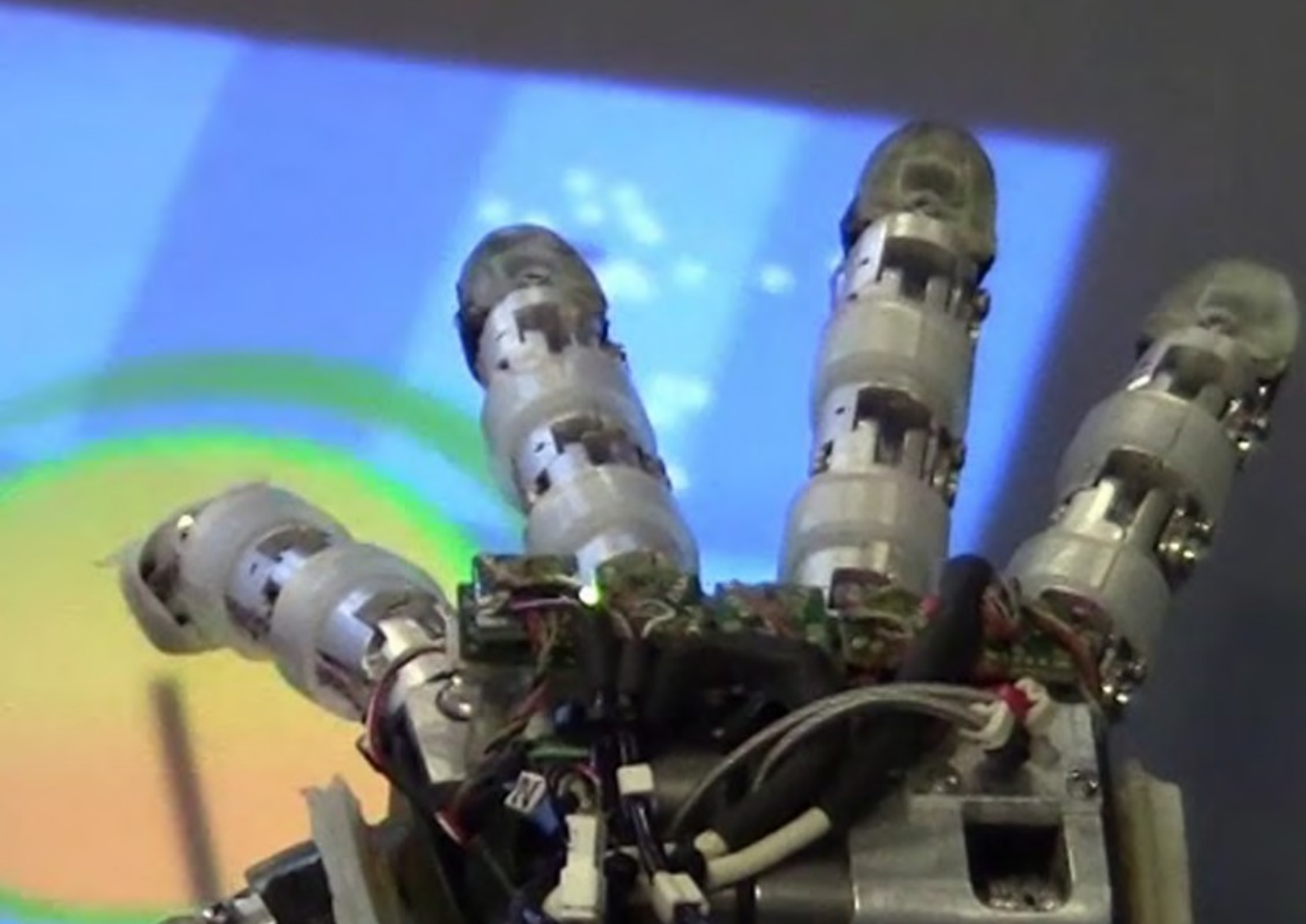
## **ON THE RDI WORKING GROUP IN ARTIFICIAL INTELLIGENCE**

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The Ministry, in line with the studies and work initiated by the European Commission in the area of Artificial Intelligence, has created a Working Group on AI (WGIA) whose main mission has been that of producing a draft that will serve as a basis for designing and approving an R&D&I Strategy in Artificial Intelligence, which will be presented at an official ceremony in March 2019.

This document was made possible thanks to the contributions of Ramón López de Mántaras (IIIA-CSIC), Josep Maria Martorell (BSC-CNS); Francisco Herrera and Oscar Cordón (UGR); Josep Lladós (CVC-UAB); Pedro Larrañaga and Asunción Gómez Pérez (UPM); Ulises Cortés (UPC); Amparo Alonso Betanzos (AEPIA); Joseba Laka and Javier del Ser (Tecnalia); Petra Fernández, Elisa Robles, David González, Francisco Salvador, and Gonzalo Remiro (MCIU).





## EXECUTIVE SUMMARY

AI was defined by J. McCarthy in 1956, as “the science and engineering of making machines that behave in a way we would call intelligent if humans had that behaviour.” AI is an area of computer science and shares some techniques with other disciplines, such as mathematics and statistics or cognitive science. Due to the growing complexity of its contributions, it is increasingly interdisciplinary, with synergies with biology, philosophy, the world of law, psychology, sociology and economics.

At this point in time, AI is one of the disciplines most likely to influence the rapid transition to a new society and economy. It is a technological revolution, which is why Spain must get involved in the development of a strategy of research, technological development and innovation that contributes to the generation of economic and social benefits in our country.

The Ministry of Science, Innovation and Universities (MCIU), in line with the 2018 Communication from the European Commission to the European Parliament, the European Council, the Council and the Economic and Social Committee on AI for Europe, and the subsequent Coordinated Plan on AI, has worked on a Spanish R&D Strategy in Artificial Intelligence. In November 2018, this Ministry created the WGIA, which is dedicated to the design of this Strategy.

The IA Strategy in RDI in Spain establishes a series of **Priorities** that will be framed within the new Spanish Strategy for Science, Technology and Innovation (EECTI) 2021-2028 and that will have to be developed in initiatives and activities defined and financed through the Science, Technology and Innovation States Plans (PECTI), mobilizing the synergies between the different levels of public administration and through the co-development of the public and private sectors. It is a condition in the development of technologies and applications of AI linked to this Strategy to avoid the negative bias and prejudices of our society, such as gender, race or other forms of discrimination, and of which the decision-making systems of AI should be free.

It also includes a series of **Recommendations** that transcend R&D and demand the presence of other sectors and ministerial departments due to the multidisciplinary and transversal nature of AI and the technological and social revolution it implies. Among these, one should mention the strategic character of the 21st century Spanish society of AI. Following the agreement of the Delegate Commission for Scientific, Technological and Innovation Policy to create an Inter-ministerial Working Group on AI in December 2018, the competent Administrations will develop a **National AI Strategy**. This National Strategy will include areas beyond RDI, which will certainly be altered by the entry of AI into society, such as the labour market, the educational model, the legislation in force and the relations within society itself with the new services and systems developed.

The Strategy sets out the following **Priorities**:

- I. To achieve an **organizational structure** that allows the development of an IA RDI system and to measure its impact.
- II. To establish **strategic areas** in which it is necessary to focus the efforts of RDI activities.
- III. To facilitate the **transfer of knowledge** and its return to society.
- IV. To plan **training and professionalization actions** in the field of AI.
- V. To develop a **digital data ecosystem** and enhance the available infrastructures.
- VI. To analyze the **IA ethics** from the perspective of RDI.

The Strategy includes the following **Recommendations**:

- I. To launch a **National AI Strategy** that allows the development and implementation of specific measures aimed at national strategic sectors. The assessment and monitoring of these measures may be carried out through a **Spanish AI Observatory**.
- II. To take advantage of AI to achieve the objectives set out in the **Agenda 2030**.
- III. To design and implement specific actions promoting the transfer of knowledge to the socioeconomic environment.
- IV. To launch or adapt **vocation promotion programs, not limited to R&D**, as well as the **attraction, retention and recovery of talent** aimed at AI.
- V. To use AI to ensure an optimal use of open data. To create a **National Data Institute** to plan and define governance over data from different levels of government.
- VI. To detect the needs of **adjustment and improvement of competences** in the different levels of our educational system.
- VII. To ensure that all the activities and initiatives derived from the strategic frameworks focused on the development of AI, as well as their results, comply with the **ethical, legal and social commitments** of our country and our European environment.



**EXPLANATORY MEMORANDUM: ELABORATION OF THE  
SPANISH STRATEGY FOR RDI IN ARTIFICIAL INTELLIGENCE**

## PREAMBLE. ON ARTIFICIAL INTELLIGENCE AND ITS HATCHING IN THIS DECADE

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IA can be defined as the Science and Engineering that allows the design and programming of machines capable of carrying out tasks that require intelligence. Rather than achieving general intelligence, current AI focuses on what is known as specific AI, which is producing very important results in many fields of application such as natural language processing or artificial vision; however, from a scientific and basic and applied research point of view, general AI remains the major objective to be achieved, that is, creating an ecosystem with intelligent multitasking systems.

It is important to point out the relevance of IA, its interdisciplinary character and its capacity to accelerate global socio-economic solutions that make it possible to bring closer the fulfilment of the Sustainable Development Objectives (SDO) of Agenda 2030. Governments are aware of this responsibility in the face of the challenges of new technologies in general and AI in particular. AI will facilitate the use of technology to guide policies that improve security and development; avoid gender and race discrimination; fight poverty; enable the deployment of aid in the face of natural disasters or universal health coverage; but it can also entail risks that we must prevent and solve by including transparency in algorithms and models, avoiding the manipulation of behaviour, taking measures to automate work, addressing the equity of models and promoting an honest use of technology.

The economic and social potential of AI is a central issue in the discussion of its possible impacts. Some studies predict that IA could add about 14 trillion Euros to the global economy by 2030 and double economic growth rates by 2035<sup>1</sup>. This new situation would change the concept of work in this process of transforming the economy and society. In addition, AI can provide a wide range of opportunities for companies by allowing a better understanding of their processes, the needs of their customers and partners, and the business environment in general. Mention should be made of the financial industry's use of these technological advances by adapting Distributed Ledger Technologies as the blockchain. AI can also enable cheaper and more personalized public services in key areas such as health and education.

As a result, governments around the world are becoming aware of the transformative power of AI for their economies, public services and labour markets<sup>2</sup> and, as a result, are increasingly recognizing the need for comprehensive national AI strategies. Many countries have now published or publicly announced policy approaches that are explicitly described as AI strategies, some of which present an associated investment plan: Canada<sup>3</sup>, China<sup>4</sup>, the United Arab Emirates<sup>5</sup>, India<sup>6</sup>, Singapore<sup>7</sup>, South Korea<sup>8</sup>, France<sup>9</sup>, Sweden<sup>10</sup>, Japan<sup>11</sup> and the countries that make up the Baltic region<sup>12</sup>.

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<sup>1</sup> <https://press.pwc.com/News-releases/ai-to-drive-gdp-gains-of-15.7-trillion-with-productivity-personalisation-improvements/s/3cc702e4-9cac-4a17-85b9-71769fba82a6>

<sup>2</sup> [Artificial Intelligence and Robotics and Their Impact on the Workplace. https://www.ibanet.org/Document/Default.aspx?DocumentUid=c06aa1a3-d355-4866-beda-9a3a8779ba6e](https://www.ibanet.org/Document/Default.aspx?DocumentUid=c06aa1a3-d355-4866-beda-9a3a8779ba6e)

<sup>3</sup> <https://www.cifar.ca/assets/pan-canadian-artificial-intelligence-strategy-overview/>

<sup>4</sup> [http://www.gov.cn/zhengce/content/2017-07/20/content\\_5211996.htm](http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm)

<sup>5</sup> <https://government.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/uae-strategy-for-artificial-intelligence>

<sup>6</sup> [http://niti.gov.in/writereaddata/files/document\\_publication/NationalStrategy-for-AI-Discussion-Paper.pdf](http://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf)

<sup>7</sup> <https://www.aisingapore.org/>

<sup>8</sup> [https://english.msit.go.kr/cms/english/pl/policies2/\\_icsFiles/afiedfile/2017/07/20/Master%20Plan%20for%20the%20intelligent%20information%20society.pdf](https://english.msit.go.kr/cms/english/pl/policies2/_icsFiles/afiedfile/2017/07/20/Master%20Plan%20for%20the%20intelligent%20information%20society.pdf)

<sup>9</sup> [https://www.aiforhumanity.fr/pdfs/MissionVillani\\_Report\\_ENG-VF.pdf](https://www.aiforhumanity.fr/pdfs/MissionVillani_Report_ENG-VF.pdf)

<sup>10</sup> <https://t.co/s2vUaaacdI>

<sup>11</sup> [https://japan.kantei.go.jp/97\\_abe/actions/201604/12article6.html](https://japan.kantei.go.jp/97_abe/actions/201604/12article6.html)

<sup>12</sup> <http://www.norden.org/sv/nordiska-ministerraadet/ministerraad/nordiska-ministerraadet-foer-digitalisering-201720132020-mr-digital/deklarationer/ai-in-the-nordic-baltic-region>

Other countries also have AI strategies contained in wider areas: UK<sup>13</sup>, Denmark<sup>14</sup>, Finland<sup>15</sup> and others, such as Germany<sup>16</sup>, will publish it in 2019 but already mark their main lines. Finally, the Italian<sup>17</sup> or Mexican<sup>18</sup> White Papers aim to inform public opinion and legislative bodies on how AI can be used to serve both individuals and businesses, thereby increasing the efficiency of public services and user satisfaction. For example, the UK's AI policy is covered in two documents: Hall and Pesenti's independent review<sup>19</sup> of the AI industry in their country, and the more recent "Industrial Strategy"<sup>20</sup>, which identifies AI as one of the four major challenges for the UK. The US approach is similarly distributed in three reports published under the Obama administration, including a specific research and development strategy paper<sup>21</sup>, as well as two broader policy documents covering possible impacts and considerations associated with AI implementation<sup>22 23</sup>.

While different in style, the content of these national AI strategies includes a number of common themes such as the use of AI in government and public services; skills and education; research, technological development and innovation; infrastructures and the ethical use of intelligent systems and data. Ethics is a central theme in almost all AI use strategies, which recognize the complex social, economic, legal and political problems raised by the widespread implementation of AI. A strong commitment to future research on the ethical use of AI is therefore needed. Although national strategies vary in scope, they tend to recognize the importance of teaching digital skills from an early stage in the national curriculum. They also emphasize the need for lifelong learning to enable workforces to adapt to new developments in technology. Likewise, strategic planning and investment in R&D is key to ensuring a competitive national AI society and industry.

In addition to the different national strategies, in the European Union (EU) following the request of the European Council of October 2017, the European Commission approved, on 25 April 2018, a "Communication to the European Parliament, the European Council, the Council and the Economic and Social Committee on AI for Europe", document COM (2018)237 final,<sup>24</sup> which is its "AI for Europe" strategy in which it presented the EU as a candidate to be a leader of the AI revolution. On the basis of this Communication, early in December the EU published the first edition of its AI Plan for 2019 and 2020, under the title "Coordinated Plan on the development and use of Artificial Intelligence Made in Europe - 2018"<sup>25</sup> (Coordinated AI Plan).

This Plan is subject to the funding framework currently in force, but is expected to be extended until 2027, under the new Multiannual Financial Framework 2021-2027. The EU proposal for public and private investment would reach a total of 20 billion Euros in the period 2018-2020 and a progressive increase of 20 billion Euros annually until 2027. The Coordinated Plan aims to ensure complementariness and synergies between actions at national and EU level to maximize the impact and spread the benefits of AI across Europe. It also provides a strategic framework for national AI strategies. EU countries are encouraged to develop their national AI strategies by mid 2019, building on work done at European level.

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<sup>13</sup> <https://www.gov.uk/government/publications/artificial-intelligence-sector-deal>

<sup>14</sup> <https://em.dk/english/news/2018/01-30-new-strategy-to-make-denmark-the-new-digital-frontrunner>

<sup>15</sup> <https://tem.fi/julkaisu?pubid=URN:ISBN:978-952-327-311-5>

<sup>16</sup> [https://www.bmw.de/Redaktion/DE/Downloads/E/eckpunkt Papier-ki.pdf?\\_\\_blob=publicationFile&v=4](https://www.bmw.de/Redaktion/DE/Downloads/E/eckpunkt Papier-ki.pdf?__blob=publicationFile&v=4)

<sup>17</sup> <https://ai-white-paper.readthedocs.io/en/latest/>

<sup>18</sup> [https://docs.wixstatic.com/ugd/7be025\\_e726c582191c49d2b8b6517a590151f6.pdf](https://docs.wixstatic.com/ugd/7be025_e726c582191c49d2b8b6517a590151f6.pdf)

<sup>19</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/652097/Growing\\_the\\_artificial\\_intelligence\\_industry\\_in\\_the\\_UK.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/652097/Growing_the_artificial_intelligence_industry_in_the_UK.pdf)

<sup>20</sup> <https://www.gov.uk/government/publications/artificial-intelligence-sector-deal/ai-sector-deal>

<sup>21</sup> [https://www.nitrd.gov/PUBS/national\\_ai\\_rd\\_strategic\\_plan.pdf](https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf)

<sup>22</sup> [https://obamawhitehouse.archives.gov/sites/default/files/whitehouse\\_files/microsites/ostp/NSTC/preparing\\_for\\_the\\_future\\_of\\_ai.pdf](https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf)

<sup>23</sup> <https://www.whitehouse.gov/sites/whitehouse.gov/files/images/EMBARGOED%20AI%20Economy%20Report.pdf>

<sup>24</sup> [http://www.europarl.europa.eu/RegData/docs\\_autres\\_institutions/commission\\_europeenne/com/2018/0237/COM\\_COM\(2018\)0237\\_EN.pdf](http://www.europarl.europa.eu/RegData/docs_autres_institutions/commission_europeenne/com/2018/0237/COM_COM(2018)0237_EN.pdf)

<sup>25</sup> <https://ec.europa.eu/digital-single-market/en/news/coordinated-plan-artificial-intelligence>

This Coordinated European Plan also aims to encourage the development of reliable AI that ensures compliance with fundamental rights and applicable regulation, as well as respect for fundamental principles and values and citizens' aspirations<sup>26</sup>. Europe will progressively increase its efforts in areas of public interest such as health, transport, security, education and energy. The Austrian EU Presidency during the second half of 2018 also included AI as a priority in the context of industrial transformation, with the intention of promoting AI as a potential field for a re-industrialisation of Europe, and establishing plans to stimulate developments in this respect, in close cooperation with relevant stakeholders. Spain, together with EU Member States, Norway and Switzerland, signed this "Declaration of Cooperation in Artificial Intelligence (AI)"<sup>27</sup>, committing to define a strategy for AI.

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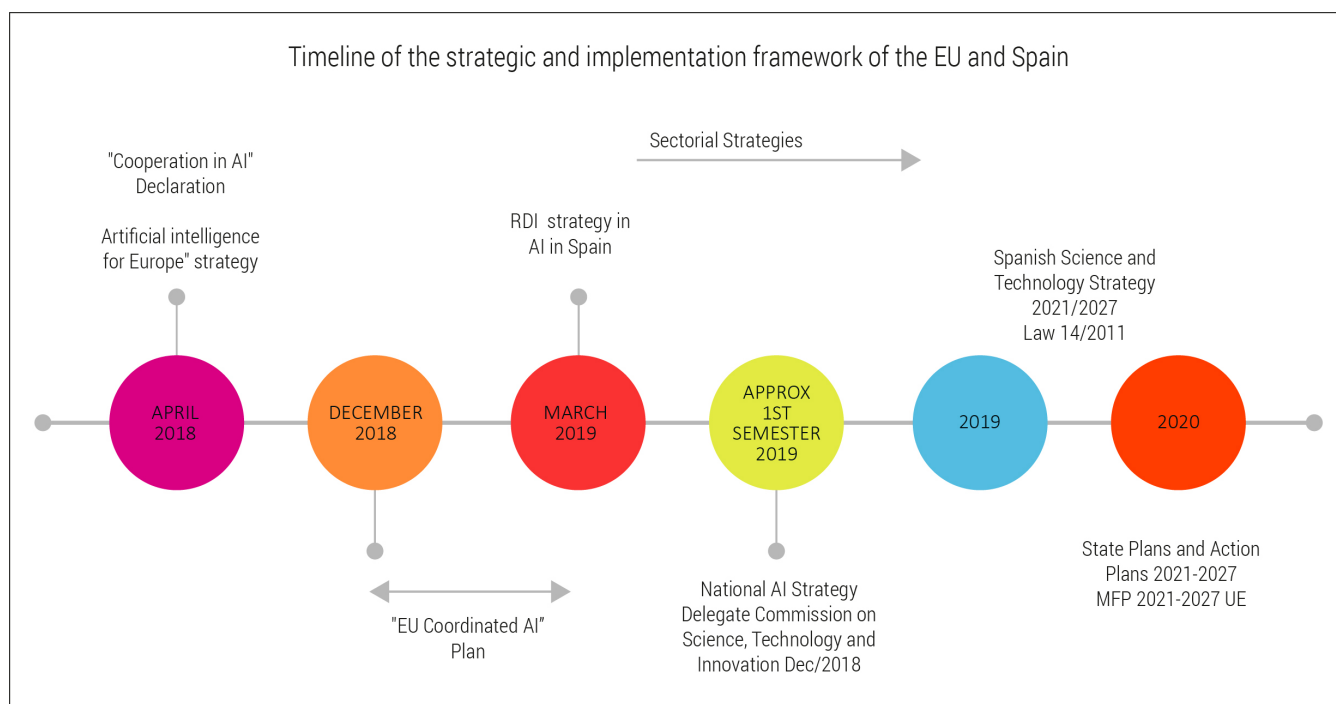
<sup>26</sup> In 1997 the Council of Europe adopted the "Oviedo Convention" <https://www.boe.es/boe/dias/1999/10/20/pdfs/A36825-36830.pdf> in which it was stated that fundamental rights are the basic foundation for guaranteeing the "primacy of the human being" in a context of technological change, and it is in a similar way that the "AI Ethical Guide" has been proposed.

<sup>27</sup> <https://ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-artificial-intelligence>

## PROCESS OF ELABORATION OF THE SPANISH RDI STRATEGY IN ARTIFICIAL INTELLIGENCE: A FIRST STEP TOWARDS A NATIONAL AI STRATEGY

By signing the above-mentioned “Declaration of Cooperation on Artificial Intelligence (AI)”, EU Member States agreed to work together on the most important issues raised by AI, from ensuring Europe’s competitiveness in AI research and deployment, to addressing social, economic, ethical and legal issues. The framework of the Strategy for AI in RDI in Spain was created to promote international RDI promotion and cooperation activities in AI and to facilitate participation in the elaboration, design and monitoring of European policies in AI and to enforce its commitment with its European partners.

The MCIU, in line with the studies and work initiated by the European Commission, has set up an AIWG. The AIRG initiated the process of elaboration of the Strategy in November 2018, chaired by the Secretary General for Science Policy Coordination of the MCIU. The AIWG was made up of experts from public and private entities of recognized national and international prestige in the field of AI, with the aim of drawing up a working document as the starting point for the process.



In addition, the coordination of the MCIU with the State Secretariat for Digital Advancement of the Ministry of Economy and Business and the Ministry of Health, Consumption and Social Welfare has allowed the departments responsible to be included with initiatives and strategic RDI actions in the General State Administration (Spanish acronym: AGE).

The phases of its elaboration have been the following:

1. Elaboration of a structure for the drafting of the strategy; preliminary priorities and recommendations emerged from the opinion of the experts that make up the AIWG, stemming from the public sphere (universities, research and innovation centres, digitalisation and large singular scientific-technical infrastructures) and the private sector



(representatives of the industrial and business sector, technological platforms and associations).

2. Elaboration of the **Spanish RDI Strategy** in AI by the MCIU, previously counting on the contributions of the Advisory Council on Science, Technology and Innovation as a participatory body of the scientific and technological community and of economic and social agents in matters related to Science, Technology and Innovation, established in Law 14/2011, on Science, Technology and Innovation. In addition, the Office of the High Commissioner for Agenda 2030 was consulted.

It should be noted that, with regard to the necessary inter-institutional coordination, this AI RDI Strategy has a dual function:

**Regarding the EECTI:** Incorporate as far as possible the Priorities of this Strategy with the aim of facilitating RDI work in the field of AI. This will allow the incorporation of an AI Strategic Axis in the future **EECTI 2021-2027**. The **EECTI 2021-2027** as a framework instrument will reflect the objectives and indicators linked to RDI which must be achieved and which will be linked to the promotion and development of actions adapted to AI activities in Spain.

**Concerning the Coordinated AI Plan:** The MCIU is fully aware of the European Commission's request to elaborate a strategic framework of AI commitment and with the creation of the "AI Inter-ministerial Group" launched by the Delegate Commission for Science, Technology and Innovation on 28 December 2018, during the first semester of 2019 active work will be done on the elaboration of a **National AI Strategy**. This National Strategy, based on the different sectorial strategies, should provide a space for co-development in common areas, a roadmap of its own and a commitment to investment, infrastructure, learning and training to create a national and European ecosystem around AI. The **National AI Strategy** should take into account autonomous strategies such as the Intelligent Specialization Strategies that should be developed through the general coordination bodies of the National Government. In the case of RDI, this communication must be made through the Council for Scientific, Technological and Innovation Policy. At a budgetary level, this sectorial convergence towards a **National AI Strategy** is perhaps even more important given that efficiency in the use of economic resources will be essential when it comes to meeting the co-financing objectives that the EU presents in its different programs (Digital Europe, the R+D+I Framework Programs of the AU 2013-2020 and 2021-2028, Horizon 2020 and Horizon Europe respectively, European Social Fund or European Regional Development Fund, among others) and for which the search for synergies and greater flexibility of financial funds and instruments will be essential.

## ARTIFICIAL INTELLIGENCE: ANALYSIS OF THE SPANISH RDI SYSTEM

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Traditionally, so-called KEY Enabling Technologies (KETs) included micro and nano-electronics, photonics, nanotechnology, biotechnology, advanced materials and advanced manufacturing systems. In a report published by the European Commission in April 2018 entitled “Industry Search: Definition of Innovation”<sup>28</sup> two new key enabling technologies for prioritization at EU level were proposed: AI and security and connectivity. Their report indicates that, with the right level of ambition for more skills, sufficient funding, a single market and social dialogue, these new KETs will contribute to supporting growth, jobs and democracy. These AI technologies already represent a turning point in the development of applications targeted at strategic sectors and innovative approaches. Our country has a solid RDI system that is enabling the creation of a science and technology-based ecosystem for AI and that still has a wide margin for growth. The impulse of this ecosystem will serve to promote and position Spain as a country that generates AI science and technology.

The action framework of the “Action Plan for the Implementation of Agenda 2030 in Spain”<sup>29</sup> reflects the leverage nature of RDI policy and therefore this Strategy is conceived with the vision of contributing to the achievement of the ODS of Agenda 2030. RDI as a leverage policy in charge of the MCIU<sup>30</sup> must include AI as a facilitating and transversal technology (a “leverage technology”). Spain, through its RDI system, is prepared to contribute to the application of AI in strategic areas aligned with the ODS such as: health; public administration; education; intelligent and sustainable cities and territories; natural resources, energy and the environment; connected industry 4.0; tourism and creative and cultural industries based on experience; and security.

### Spanish position in the development and use of AI technologies

The situation of Spain together with that of other surrounding countries has been analysed through different studies. A recent OECD report<sup>31</sup> indicates that private equity investment in start-ups focused on AI in Spain between 2011 and mid 2018 is 3% of the total amount invested in start-ups based in the EU, well behind France (13%), Germany (14%) or the United Kingdom (55%). According to the study carried out by the consulting firm Roland Berger “*Joining the dots- A map of Europe’s AI Ecosystem*”<sup>32</sup>, the four most important AI countries in Europe are the United Kingdom, France, Germany and Spain, which contribute 60% of start-ups, laboratories and communities<sup>33</sup> of the 30 countries analysed (EU, plus Switzerland and Norway). Although the first three countries alternate in terms of the different measures used (for example, the United Kingdom clearly stands out in the number of start-ups and France in the number of laboratories), Spain ranks fourth, closely followed by countries classified in the group of emerging countries as the so-called “followers”. These data show that there is ample room for improvement with a better system of cooperation between agents and that the technological investment made so far in Spain is insufficient and that, in short, without solving these two aspects there will not be a favourable environment for AI technologies in our country. However, the situation in the EU is also not very encouraging when we observe that these EU investments account for 8% of global investment in 2017 (China and the US account for almost 85% of investment).

<sup>28</sup> <https://publications.europa.eu/en/publication-detail/-/publication/28e1c485-476a-11e8-be1d-01aa75ed71a1>

<sup>29</sup> <http://www.exteriores.gob.es/Portal/es/SalaDePrensa/MultimedAI/Publicaciones/Documents/PLAN%20DE%20ACCION%20PARA%20LA%20IMPLEMENTACION%20E%20LA%20AGENDA%202030.pdf>

<sup>30</sup> This universal contribution of RDI to the achievement of the ODS will be specifically considered in the next EECTI 2021-2028. Spain, in the same line and for the next EU R&D and Innovation Framework Programme 2021-2027, defends the inclusion of the SDOs as framework conditions in the priorities and objectives of the programme itself in the development and implementation of EU policies. SDOs must be key in the direction of funding programmes and in the development and implementation of mission-orientated EU policies, research and innovation in R&D activities.

<sup>31</sup> <http://www.oecd.org/going-digital/ai/private-equity-investment-in-artificial-intelligence.pdf>

<sup>32</sup> <https://www.rolandberger.com/fr/Publications/Joining-the-dots-A-map-of-Europe-s-AI-ecosystem.html>

<sup>33</sup> Ranging from informal groups to summer schools, congresses and public-private associations.

Despite this, the European Commission's *The European AI Landscape*<sup>34</sup> report gives evidence of Europe's leading role in being “at the forefront of AI and robotics, as evidenced by the excellent scientific position of European researchers, including several world experts in AI from Europe.”

This European situation, characterized by insufficient public and private investment in a context of a global race to develop and incorporate AI technologies in the different areas of socio-economic impact, requires Spain to play a leading role, as is expected of our capabilities, with AI research groups of excellent international level, and where most universities already offer relevant engineering programs. University training in AI has some of the oldest and most consolidated postgraduate, masters and doctoral programs in Europe with more than 3 decades of history. According to RD 1393/200735 and RD 99/201136, which regulate official university and doctoral education, there are 11 current Master Courses and 2 doctoral programmes, although there are other official programs that include the study of AI in their curricula.

### Spanish research in AI

Spain's pioneering role in AI should be underlined. Between the end of the 19th century and the 20th century, Leonardo Torres Quevedo included cybernetics, a precursor of AI, among his numerous areas of work. Torres Quevedo made the first demonstration of chess automation in 1912 with his electromechanical chess automaton capable of consistently making checkmates by playing with the final white pieces of the game: King and Rock versus King. Throughout the history of AI, automating chess has been one of its main objectives. Claude Shannon, Marvin Minsky and other founders of the AI dedicated efforts to try to automate chess in the late 50's and it was in 1997 when IBM's Deep Blue program beat Kasparov.

Currently, the Spanish academic and scientific community dedicated to AI technologies is characterized by its international recognition in most of its areas, such as: machine learning, heuristic optimization, planning, automatic deduction, ontologies, logic and reasoning, big data, natural language processing, artificial vision, robotics, multi-agent systems, recommender systems, man-machine cooperation, agent-based modelling, as well as by the development of innovative applications in a large number of strategic sectors such as health, agriculture, cultural industries and based on experience, services and energy and environmental sustainability.

The Spanish Science, Technology and Innovation System (Spanish acronym: SECTI) dedicated to AI includes not only publicly and privately owned academic and scientific institutions, but is also completed by associations and organizations supporting RDI, companies and society. The network of support and support agents whose object is the promotion of AI in Spain are entities, mainly associations<sup>37</sup>, which play an active role in the system, promoting training activities, dissemination at a regional, national or international level in different AI technologies. In the private sector, activity in AI<sup>38</sup> is growing rapidly both through start-ups and in large companies and multinationals with initiatives focused on the creation of R&D centres in AI technologies.

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<sup>34</sup> [https://ec.europa.eu/knowledge4policy/publication/european-ai-landscape\\_en](https://ec.europa.eu/knowledge4policy/publication/european-ai-landscape_en)

<sup>35</sup> <https://www.boe.es/buscar/act.php?id=BOE-A-2007-18770>

<sup>36</sup> <https://www.boe.es/buscar/act.php?id=BOE-A-2011-2541>

<sup>37</sup> There are 5 scientific associations in Spain related to AI, the Spanish Association for AI (AEPAI), the Spanish Society for Research and Development in Robotics (SEIDROB), the Spanish Society for Natural Language Processing (SEPLN), the Spanish Association for Form Recognition and Image Analysis (AERFAI) and the Associació Catalana d'Intel·ligència Artificial (ACAI).

<sup>38</sup> [http://ec.europa.eu/newsroom/dae/document.cfm?doc\\_id=50821](http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=50821)

## AI Indicators

Specific indicators are currently being established that attempt to overcome methodological difficulties in measuring the use of AI technologies. These efforts include private initiatives that seek to bring to the forefront the way in which national governments present in the OECD are strategically positioned in their ability to reap the benefits of automation in their operations by creating the *Government AI readiness index*<sup>39</sup> that was conceived for understanding the ability to absorb and exploit the innovative potential of AI in AAPP (Public Administration) services. The index incorporates the country's digital skills, government innovation and existing data capabilities. This index<sup>40</sup> places Spain in the twelfth position of OECD countries (ahead of Sweden and behind Germany) and identifies areas for improvement focused mainly on telecommunication infrastructure, innovation development or digital skills linked to both the public and private sectors.

The growth of both is conditioned not only by investment in RDI but also by the digital divide in Europe<sup>41</sup> identified as one of the reasons why Spain<sup>42</sup> lags behind European countries or the USA and China. This is due to a clear room for improvement in efforts to develop the digital technology and tools that are the most important precondition for the spread of AI. In the 2019 study by the McKinsey Global Institute entitled "Addressing the Digital Europe and AI Divide"<sup>43</sup> companies identify the development of complementary strategies and worker skills in keeping with AI technology advances as a major influencing factor for the adoption of AI. In fact, it is considered essential to have a properly trained workforce and to be able to meet the need for AI applications and services capabilities.

In this study they compile a set of indicators per country (weighted by their relative importance to boost the economic growth of each country) to evaluate how they are placed in the key enablers, and add them in an AI Preparation Index<sup>44</sup>. In this study, our country ranks eleventh in the EU. Spain is below the European average in this index as well as in the number of AI start-ups per capita, the creation of ICT business models, RDI spending and ICT connectivity; only in automation and digital maturity is it in the European average. Spain is in the last quartile in terms of AI skills, and therefore in a serious situation in terms of the potential of work activities and the availability of scientists and engineers in this area.

It is essential for the improvement of opportunities for Spanish companies to recruit, retain and train (and for the companies themselves participate in this training) the right talent with the skills needed for AI technologies. A recent study on job skills changes predicts a significant increase in the demand for social, cognitive and digital skills, and expects that technology-driven talent will have an estimated relative increase of 41% in Germany and 66% in Spain (a 20% increase in emotional or social skills and a 20% decrease in manual or physical skills) by 2030<sup>45</sup>.

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<sup>39</sup> <https://www.oxfordinsights.com/government-ai-readiness-index/>

<sup>40</sup> This index takes into account the following factors: Public Service Reform (Innovation, Digital Public Services Government Effectiveness); Economy and skills (Digitalization, Technological Skills, AI Start-ups) and Digital Infrastructure (Quality, availability and data capacity)

<sup>41</sup> The ICT sector (2017) in Europe today accounts for about 1.7% of GDP, less than China's 2.2% and half of the US GDP of 3.3%. Source DG Research and Innovation, European Commission.

Spain devotes 1.3% of its GDP to ICT in 2017. The digital part of the ICT value added is calculated by taking the share of income obtained through digital channels and taking the share of the cost of all functions performed digitally. Source DG Research and Innovation, European Commission.

<sup>43</sup> <https://www.mckinsey.com/~medAI/McKinsey/Featured%20Insights/Artificial%20Intelligence/Tackling%20Europes%20gap%20in%20digital%20and%20AI/MGI-Tackling-Europes-gap-in-digital-and-AI-Feb-2019-vF.ashx>

<sup>44</sup> The index measures the position of countries in a range of AI enablers, including the number of AI start-ups per capita, automation, potential of work activities, digital maturity, availability of scientists and engineers, creation of ICT business models, R&D expenditure and ICT connectivity using Eurostat; INSEAD; DG Research and Innovation, European Commission; PISA report; UNESCO; McKinsey Global Institute AI Diffusion Model; McKinsey Global Institute analysis. Skill shift: Automation and the future of the workforce, McKinsey Global Institute, May 2018.

## ARTICULATION MECHANISMS AND FINANCING INSTRUMENTS

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The EECTI 2013-2020 and its State Plans have allowed a simplification of the management of state R&D, creating a shared RDI space at a national level and open to Europe, actively contributing to the development and implementation of the European Research Area. The common objectives set at a strategic level have allowed the agents of our SECTI to compete in a globalized and dynamic environment. In addition, the co-responsibility of the Administrations is responding to a functional reality that undoubtedly leads us to a stable framework of shared political and administrative collaboration. This new situation represents an ideal environment to facilitate the articulation and incorporation into the new post 2020 strategic framework of new strategic lines of RDI that at a global level already have a real impact on public policies and interventions in the area of RDI.

The MCIU's 2017-2020 State Plan for Scientific and Technical Research and Innovation consists of four State Programmes<sup>46</sup>: (1) Talent and its Employability in RDI; (2) Generation of Knowledge and Scientific and Technological Strengthening of the R+D+I System; (3) Business Leadership in RDI and (4) RDI Oriented to the Challenges of Society. Through these Programmes, activities aimed at the strategic areas identified in this AI RDI Strategy have already been financed. These programs are completed with several strategic actions, among which the Health Action, the Digital Economy and Society Action and the Connected Industry 4.0 Strategic Action (included as a novelty of the 2017-2020 State Plan) mark the strategic importance of AI. These tools, which are subject to the state budgetary framework, allow for the immediate development of this Strategy, through the aforementioned programs and subprograms of the State Plans and in coordination with the different RDI actions of the different Autonomous Communities (CCAA).

For the management of these Programmes, the National Government has several financing agents for the exercise of its policies for the promotion of RDI. The MCIU's agents are the State Research Agency (AEI) and the Centre for Industrial Technological Development (CDTI). The AEI is responsible for the management and financing of public funds allocated to RDI activities according to scientific merit, while the CDTI is essentially aimed at promoting technology-based innovation by allocating its resources according to technical and market merit and socio-economic impact. Sectoral funders include: the Carlos III Health Institute, which manages the activities of the Strategic Action on Health; the Secretary of State for Digital Advancement (SEAD) of the Ministry of Economy and Enterprise (MINECO) finances projects and actions within the Digital Enabling Technologies through the Natural Language Technologies Plan 2015-2020 and the Strategic Action in Digital Economy and Society; and the Ministry of Industry, Trade and Tourism (MINCOTUR) is responsible for the Strategic Action Industry 4.0. All these bodies are essential to improve the implementation of this Strategy and to carry out coordination tasks with their European counterparts, an essential aspect in the development of actions and activities related to AI.

The contributions made by the state bodies financing RDI, CDTI, AEI, ISCIII, MINECO and MINCOTUR, to the activities contributing to AI have involved 457 actions worth almost 114 million euros in financing (subsidies and credits)<sup>47</sup>. These actions have been granted through the tools offered by the four State Programmes developed in the State Plans and their Strategic Actions included in the EECTI 2013-2020 and the Natural Language Technologies Plan (2016-2018 calls). In the same period for the R&D Framework Programme H2020 there was Spanish participation in 116 actions related to AI that obtained a funding of € 79.30 million.

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<sup>45</sup> It is essential to underline the strategic nature of the State R&D and Innovation Plans referred to in article 8.1 of Law 38/2003, of 17 November, on General Subsidies. The allocation of public funds through state plans will be granted in accordance with the principles of publicity, transparency, competition, objectivity, effectiveness and non-discrimination, with the aim of correcting the challenges and failures identified in said plans by the granting Administration and through efficiency in the allocation and use of public resources provided for in said Law.

<sup>46</sup> Funding data obtained through AEI, CDTI, ISCIII, MINECO, MINCOTUR using keywords within AI technologies

**ESTIMATION OF THE NUMBER OF ACTIONS, FUNDING AND TOTAL COST LINKED TO TECHNOLOGIES IN THE DIFFERENT NATIONAL PLANS AND THE RDI FRAMEWORK PROGRAMME H2020**

|   |  | # actions | Financing M€ | Total M€ |
|---|--|-----------|--------------|----------|
| EECTI 2013-2020<br>PECTI 2013-2016 and<br>2017-2020       | State Programme for Business Leadership in RDI   | 107       | 37.69        | 53.55    |
|   | State Programme for the Generation of Knowledge and the Scientific and Technological Strengthening of the RDI System*. | 73        | 16.09        | 16.09    |
|   | State RDI Program Oriented to the Challenges of Society**  | 67        | 21.04        | 21.04    |
|   | State Talent and Employability Programme in RDI  | 51        | 5.37         | 5.37     |
|   | Strategic Health Action (MSCBS)  | 16        | 1.54         | 1.54     |
|   | Strategic Action Connected Industry 4.0 (MINCOTUR)   | 69        | 24.17        | 31.56    |
|   | Strategic Action AEESD (MINECO)  | 42        | 4.22         | 4.22     |
| Plan for the Promotion of Language Technologies 2015-2020 | MINETAD (calls 2016-2018)  | 32        | 3.51         | 3.51     |
| Horizonte 2020  | ICT H2020  | 116       | 79.30        | 83.30    |
|   |  | 573       | 192.93       | 220.18   |

Funding data provided by AEI, CDTI (contribution commitment), ISCIII, MINECO, MINCOTUR using keywords from AI technologies.

\* It has been considered that the Severo Ochoa and Maria de Maeztu centres and units allocate 15% of their contributions to RDI activities linked to AI technologies.

\*\* Includes Spanish contribution to ECSEL JU.

The coordination of these financing agents and their instruments will make it possible to improve the financing instruments and mechanisms for articulating RDI activities through the following initiatives:

- Within the framework of the competencies of the MCIU, the assumption of measures, reforms and design of instruments that raise the levels of investment and participation of the national private sector and facilitate the development of an ecosystem of AI technologies. They will also be aimed at promoting the attraction of foreign investment and investment by foreign companies.
- The tools (including Programmes, Sub-programmes and calls) should favour the generation of new knowledge and technologies of a disruptive nature, and new uses of existing technologies (of an incremental nature). They should contribute to increasing their productivity and competitiveness in strategic sectors in which AI will be implemented to a greater or lesser extent.
- Open access to data and micro-data, as well as to publications, code (software), and results of publicly funded research, incorporating the elaboration of guidelines that provide own or shared repositories, thus facilitating the public use of AI and data generated in the different fields of application.
- The co-responsibility of all Public Administrations in the achievement of the objectives and the commitment with the established priority axes, including the implementation of instruments that make possible the financing of RDI that facilitates the use and development of AI technology in various fields. This vision should be complemented with a legislative analysis that foresees the inclusion/acceptance of those advances and developments of AI innovations and an analysis of the impact of AI on the labour market, education and training.

- The co-responsibility of all Public Administrations in establishing improvement mechanisms in: the coordination of financing agents; access to financing; and in increasing the effectiveness of the instruments currently in force.

## CHARACTERISTICS OF ARTICULATION MECHANISMS AND FINANCING INSTRUMENTS

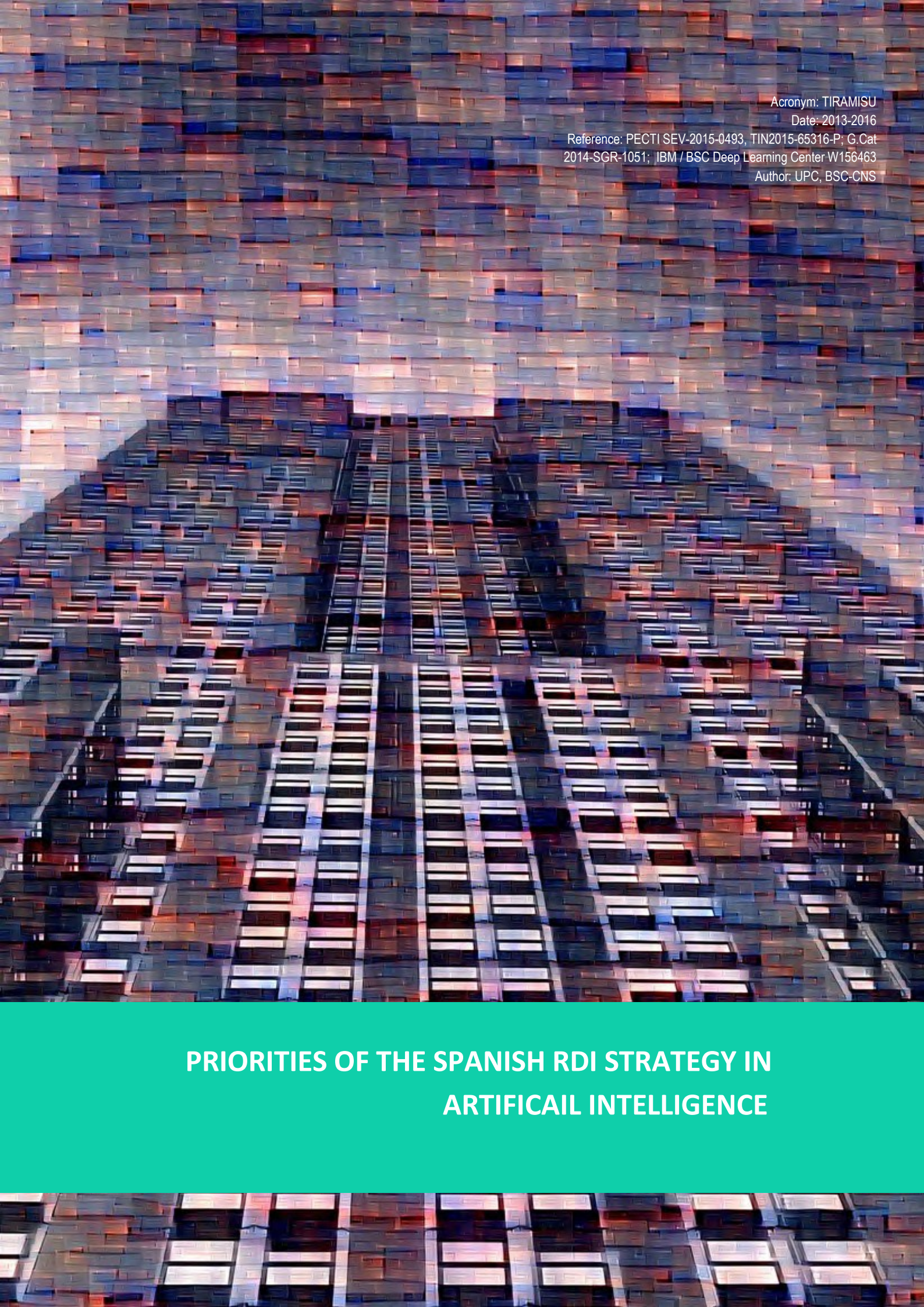
Instruments incrementing the investment of the national and international private sector

Maintaining open-access data, results, publications and codes

Co-responsibility of the Public Administrations in the development of the priorities established in the Strategy

Mechanisms that allow the implementation and use of AI technologies in the different priority sectors

Mechanisms for improving existing instruments and access to funding



Acronym: TIRAMISU

Date: 2013-2016

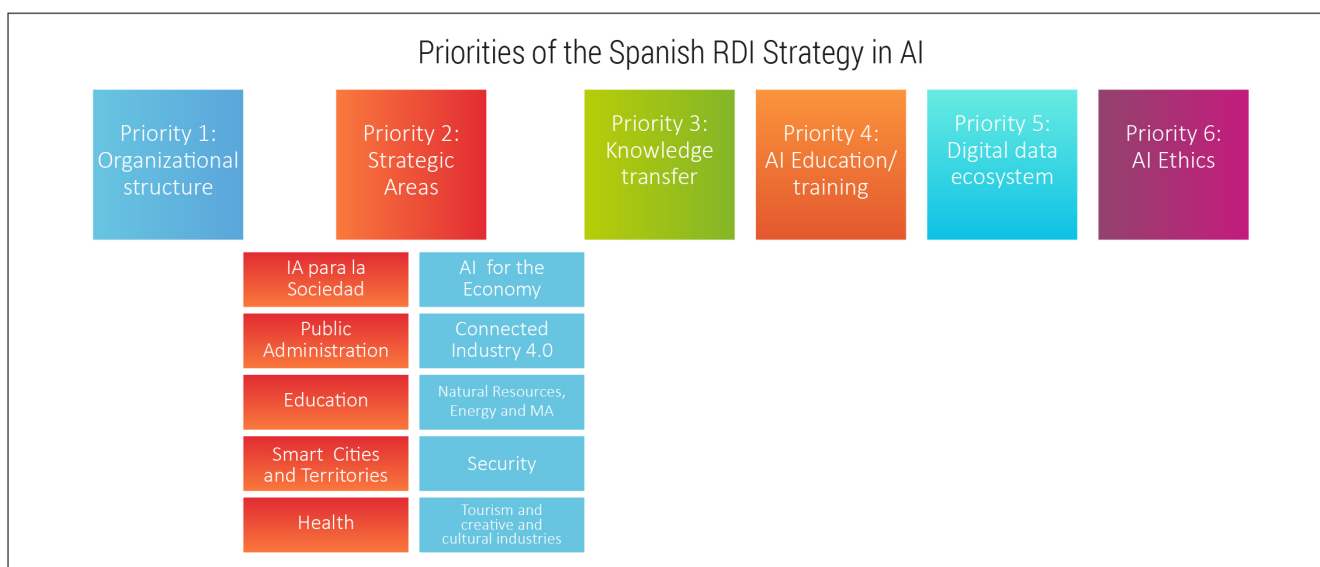
Reference: PECTI SEV-2015-0493, TIN2015-65316-P; G.Cat  
2014-SGR-1051; IBM / BSC Deep Learning Center W156463

Author: UPC, BSC-CNS

## **PRIORITIES OF THE SPANISH RDI STRATEGY IN ARTIFICIAL INTELLIGENCE**



The following Priorities raise aspects of the SECTI to be developed to create the appropriate ecosystem for the development and application of AI technologies. These Priorities will be developed in initiatives and activities defined and financed through the PECTI and those specific State Plans of the different ministerial departments that make up this system and specifically aimed at RDI activities. The set of indicators that will make it possible to measure the degree of execution of these activities and initiatives related to AI and the monitoring of the results will be those established in the EECTI and in the AI National Strategy.



## **PRIORITY # 1. TOWARDS AN ORGANISATIONAL STRUCTURE THAT ALLOWS THE DEVELOPMENT OF AN RDI SYSTEM IN AI AND THE ASSESSMENT OF ITS IMPACT**

| <b>PRIORITY # 1</b>   |
|---|
| Maintain as good practice and reinforce the strategic alignment of Spain's RDI policies with the EU and its RDI Framework Program, guaranteeing Spain's global competitiveness. |
| Launch an AI Capability Map   |
| Support the launch of a Network of nodes in order to achieve a "Network of Centres of Excellence in AI".  |
| Promote the interaction of such networks with the DIH.  |
| Highlight the role of the Spanish Ethics Committee in research into the use and implementation of AI.   |
| Establish a series of indicators that allow the analysis of the evolution of promotion mechanisms in RDI in AI.   |

The framework of the EECTI 2013-2020 and its State Plans have made it possible to strengthen all the capabilities of the SECTI and to facilitate collaboration and interaction between all the System's agents, as well as its internationalization, which has contributed to national and European economic and social progress.

One of the reasons that have undoubtedly contributed to this progress has been the effort made by the entire public administration to align Spanish policies with the objectives pursued by the EU in RDI material. This effort has increased the active participation of the public and private agents of the SECTI in the European programs and as a consequence it has contributed to the consolidation of the European Research Area, the objectives of the "Europe 2020" strategy, the "Innovation Union", the "European Research Area" and the Horizon 2020 Framework Program. The work aimed at developing the **EECTI 2021-2027** and its future implementation framework, the State Plans for Science, Technology and Innovation (PECTI), already foresee a new global situation marked by the Agenda 2030. Their inclusion in the next cycle of the EECTI is foreseen by ensuring a reliable, safe and inclusive development of AI technologies and equitable access to their benefits. The proximity of a **new multiannual financial framework 2021-2027, the future EU R&D Framework Program Horizon Europe** and the future "Digital Europe" Program reinforce the need to continue with what is considered good practice, i.e. the strategic alignment of Spain's RDII policies with the EU and its Framework Program.

In the new period 2021-2027, significant space must be opened up to new technologies, services and multidisciplinary ecosystems such as AI, which will undoubtedly facilitate greater social and economic progress, but also, in a context of social and economic fragility in Europe, should pay specific attention to social integration through education, ethics and legislation.

At the international level, Spain should promote and participate, through its RDI agents, in European and international proposals and programs deriving from the Coordinated AI Plan that guarantee the EU's global competitiveness in this sector, such as, among others, the exchange of good practices, positioning with respect to new public-private partnerships or the elaboration of a common strategic program of research, data, ethics or AI education at the European level. An important part in the promotion of RDI activities of the Spanish scientific community in the EU is the work carried out by the network of national agents in the Horizon 2020 and Horizon Europe Programs, for the participation of Spanish entities in joint initiatives related to AI (ECSEL<sup>47</sup>, JU EuroHPC<sup>49</sup>, QuantERA<sup>50</sup> and Quantum Technology Flagship<sup>51</sup>, among others).

In order to take full advantage of these opportunities for European cooperation and to achieve effective national and international organizational coordination and public and private sector coordination, it is recommended to draw up a **Map of current AI capabilities in Spain** and to launch a **"Network of AI Research Nodes"**. This action will promote the consolidation of agents, creating and maintaining over time an active and competitive scientific-technological community in the field of IA technologies. In addition, an efficient use of existing instruments and the creation of new ones, in order to join forces and generate synergies, will boost RDI activities in AI. The ultimate aim will be the creation of a **"Network of Centres of Excellence in IA"** from this Network of Nodes, which will execute a good part of the RDI actions derived from this strategy and which will form part of the European network. These excellence centres would largely be formed by the main national AI RDI centres as well as the Severo Ochoa Excellence Centres and María de Maeztu Excellence Units with significant dedication to AI research and which are financed under the current Subprogram for Institutional Strengthening of the State Plan for Scientific, Technical and Innovation Research.

In addition, the **Nodes and Centres** of this Network should be able to attract and retain both national and international talent and, in particular, recover part of the talent that has left Spain in recent years; develop network activities in areas contained in this Strategy such as specific training. It is important that its structure allows going beyond the scientific field promoting an own vision that has a real impact on public policies.

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<sup>47</sup> <https://www.ecsel.eu/>

<sup>48</sup> <http://eurohpc.eu/>

<sup>49</sup> <https://www.quantera.eu/>

<sup>50</sup> <https://qt.eu/>

An essential part of this organizational structure is the development of the agents and instruments that allow **the transfer of knowledge from the academy to companies** which, traditionally understood in the context of public-private collaboration projects financed by a third party (EU, MCIU, CCAA); University-Company Chairs and projects commissioned by the companies from the University or Public Research Bodies. The creations of associated centres or units, consisting of R&D departments of companies and research structures of research organizations, and knowledge and technology based enterprises (KTEs) have also been an important route for the transfer of AI. These collaborative structures must be adapted and supported to improve the application of the technologies developed through AI.

The **Digital Innovation Hubs** (DIH)<sup>52</sup> are an instrument, created and promoted at European level, to enable the transfer of knowledge between scientific centres and companies with greater agility in a given region. DIH is a current example of cooperation between different RDII actors in a region to strengthen the innovation ecosystem, helping companies to become more competitive by using digital technologies through a one-stop shop. In line with the call for DHIs in the EU which selects DHIs in the topics of Artificial Intelligence<sup>53</sup>, at state level the establishment of an ecosystem should be promoted which is accessible and has the commitment of SMEs and which allows for regional and national cooperation schemes between the different digital and physical infrastructures. Within the framework of ministerial cooperation of this Strategy, it will correspond to the Ministry of Industry, Trade and Tourism (MINCOTUR) through the Connected Industry Strategy the development of the digitalization of the industry as well as the definition of the model of DHI in Spain. DHI allows the promotion of the shared use of testing facilities and laboratories and the exchange of theoretical and practical knowledge.

Complementarily, the networks of Nodes and Centres of Excellence should be aligned with regional DHI, thus fostering **cooperation between the different agents** in this new organizational structure and promoting a new RDII ecosystem in AI, the synergistic use of which would accentuate the use of its resources and its effort in innovation activities.

This new organizational structure should recognize the role of ethics in the design and use of AI in the RDI sector, which corresponds to the **Spanish Committee on Research Ethics (CEEI)** and which is developed in Priority 6. It should correspond to the CEEI (article 10 of Law 14/2011, of 1 June, on Science, Technology and Innovation) that will lead the activities and reports, proposals and recommendations on the scope of the AI in Spain. The agents in charge of these actions should play an active role in ethics-focused initiatives and ethics observatories for international and European AI<sup>54</sup>.

In order to assess the impact of the specific measures implemented by the PECTI through the proposed organizational structure, the indicators **available** in the Information System on Science, Technology and Innovation<sup>55</sup> should be taken into account as the main instrument for data collection and analysis for the preparation and monitoring of the EECTI. In addition, account will be taken of those provided by the National Statistics Institute<sup>56</sup> and the work carried out in the EU<sup>57</sup> to verify the state of compliance with the ODS goals and, therefore, as a guarantee of the success of Agenda 2030 in Spain in general and of the impact of RDI as a lever policy in particular. Taking into account the strategic value of the AI in the SECTI, as determined by the Delegate Commission for Science, Technology and Innovation Policy in December 2018, it would be appropriate that the indicators selected for the development of future PECTI discriminate between funding and investment directed at AI activities as well as their impact, not only in terms of data generation or publications but also in the transfer of knowledge and its impact on the economy.

<sup>51</sup> <http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-catalogue>

<sup>52</sup> <https://ec.europa.eu/digital-single-market/en/news/call-digital-innovation-hubs-artificial-intelligence>

<sup>53</sup> <https://ec.europa.eu/digital-single-market/en/news/artificial-intelligence-ai4eu-project-launches-1-january-2019>

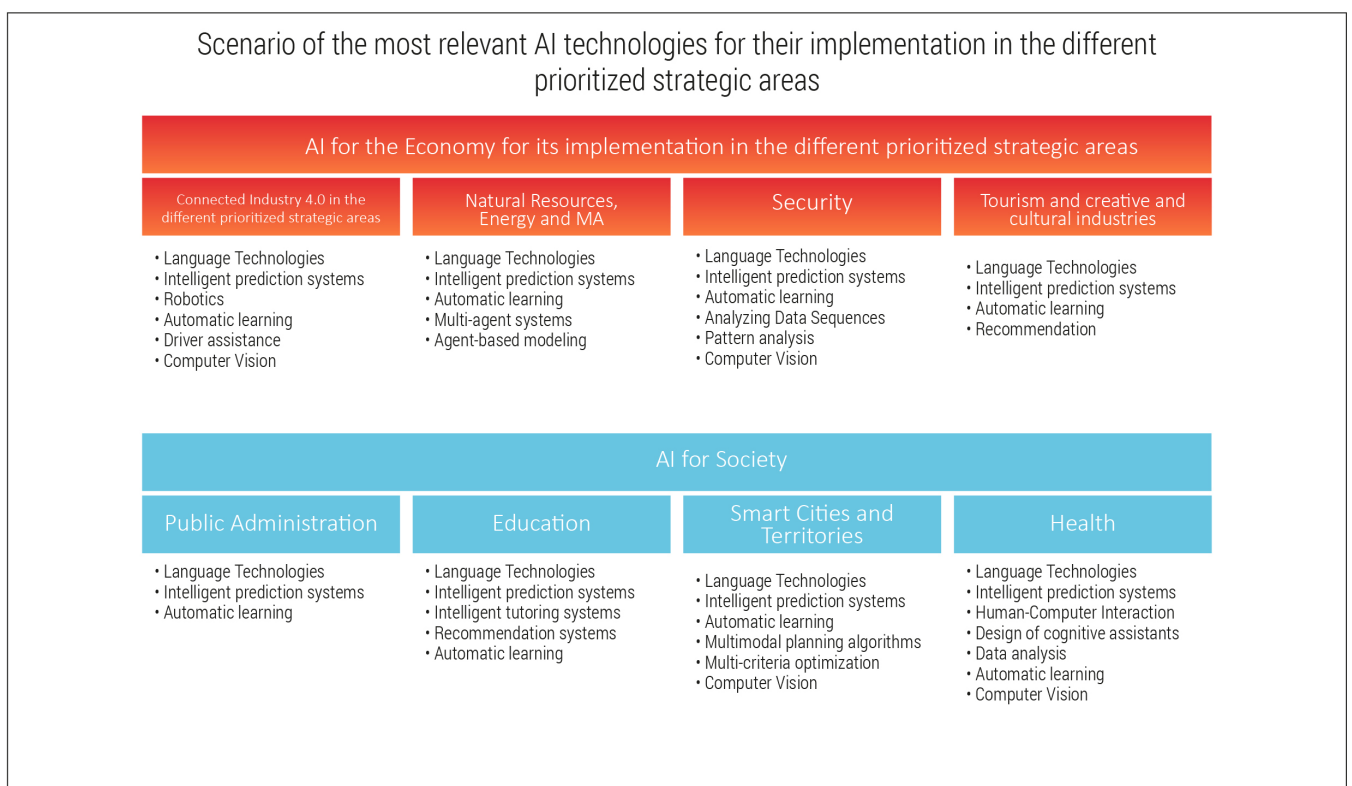
<sup>54</sup> <http://www.ciencAI.gob.es/portal/site/MICINN/menuitem.8ce192e94ba842bea3bc811001432ea0/?vgnextoid=8e5db1c445673410VgnVCM100001d04140aRCRD>

<sup>55</sup> <https://www.ine.es/dynt3/ODS/es/index.htm>

<sup>56</sup> [https://ec.europa.eu/knowledge4policy/ai-watch/topic/ai-landscape-indicators\\_en](https://ec.europa.eu/knowledge4policy/ai-watch/topic/ai-landscape-indicators_en)

## PRIORITY # 2. ESTABLISH STRATEGIC AREAS WHERE TO DEVELOP RDI ACTIVITIES IN AI

| PRIORITY 2   |
|--|
| Key AI technologies for the development of priority sectors of the Spanish economy and society   |
| The humanities and social sciences have a cross-cutting character and are incorporated into all sectors  |
| The application of AI technologies varies according to the strategic area and the degree of maturity and development in the incorporation in each sector |



The commitment to RDI as a policy to accelerate progress in the establishment of socio-economic synergies, and the role that IA should have as a transversal facilitating technology, reflects the spirit with which Law 14/2011, on Science, Technology and Innovation, was born. It is there where this policy demands the generation of knowledge in all fields, its dissemination and its application to obtain a social or economic benefit and with a multiplying effect in its impulse towards a sustainable development in sectorial and transversal policies at a global level.

It is for this reason that the EECTI and the State Plans for Research, Development and Innovation show a transversal character that requires close coordination in the different areas of Public Administration. This cross-cutting nature facilitates activity in strategic sectors of 21st century Spanish society and requires the co-development of complementary programmes within an innovative environment that responds to the major challenges facing society, to

the missions that will be set out in the Horizon Europe Program, that facilitate the acquisition of new skills and the incorporation of talent, that strengthen our country's international leadership and collaboration in R&D&I, and that promote the participation of civil society and its organizations in the innovation process.

The horizontal nature of the strategic framework of R&D in AI perfectly fits with the need to establish the sectors of our society that require advances based on AI technologies and where the Spanish scientific and academic community has a notable international relevance.

In addition, the AI developed in Europe must guarantee that human values and fundamental rights are central, ensuring that the goal of technology is to increase the level of well-being of citizens. For this reason, research in **Social Sciences and Artificial Intelligence**, as well as in digital humanities, should be considered as a cross-cutting vector in all strategic areas included in this Priority. Areas such as ethics, psychology, philosophy, linguistics, law, in particular the legal and regulatory aspects of AI, as well as intelligent systems that model phenomena and social systems will be necessary. This type of systems will allow us to design short, medium and long term strategies that will help us to plan and react to the social phenomena that occur, in a society with consumption habits and lifestyle changes, as well as generate recommendations to adopt the most appropriate social policies.

The strategic areas identified cover a broad spectrum of use cases, allowing the potential of AI to be extended to all sectors of society. The maturity of each strategic area and each economic and social sector allows for the deployment of projects that, through AI, will be aimed at strengthening the innovation capabilities and competitiveness of the sectors themselves. AI technologies will be developed, conceptualized or applied through innovations in applications, including incremental ones, in different areas. The concept of innovation linked to the actions of AI should not be limited to the technological character, but should seek dimensions that, like those associated with new applications and uses, generate added value, contributing to the improvement of productivity and competitiveness of public administration and business.

In all these areas, opportunities open up for the generation of multidisciplinary and disruptive knowledge, technologies and innovations in AI, while promoting the combination of fundamental and applied research and experimental development.

RDI faces the difficult task of facilitating and improving the incorporation of enabling technologies based on the AI thanks to solutions that seek hybridization between the physical and digital world, and with a real impact on the strategic areas and sectors of the socioeconomic model of our country. We will therefore talk about areas that converge into an AI for Society and an AI for Economy that correspond to the backbone sectors of our country and that will contribute more and more to the development of the different dimensions of the Welfare State in Spain<sup>57</sup>, taking into account the transversal nature of the Humanities and the Social Sciences in all sectors.

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<sup>57</sup> <https://www.oecd.org/statistics/Better-Life-Initiative-country-note-Spain-in-Espagnol.pdf>

### Public Administrations

IA is called to be a catalyst for the transformation of the activity and digital presentation of the public administration<sup>59</sup>. As cities, regions and states continue to adopt the most modern information technologies, the everyday tasks of public employees are transformed. Since the public sector is the largest producer and manager of data on individuals - citizens and tourists -, on companies - public and private - and the services it provides, it is natural that AI, and in particular the analysis of data through machine learning, should be key in the management of public administrations.

The use of *chatbots* based on the **natural language processing** as the first interface between citizens and Public Administrations already makes it possible -for example in the USA- to reduce response times and increase the ability to focus public officials on tasks of greater social value. For example, in local government, there are three key areas of citizen interaction: (a) high volume and low complexity transactions, such as forms; (b) high complexity and low volumes, such as social assistance, and in the middle, (c) those with medium complexity and medium volumes such as permit planning and tax collection.

One sector of the Public Administrations in which the AI is crucial is that of the National Security Strategies<sup>60</sup>, in which AI is beginning to be applied already. For example, building information systems that unify criteria, share information and analyze all entries - in different formats - favouring collaboration between the security forces and corps of different countries<sup>61</sup>.

Another sector where the IA can improve the performance of the Public Administrations is to ensure interoperability between administrations and generate automated administrative procedures where **natural language processing techniques** and language technologies are essential in the use of co-official languages. It is also worth noting the use in the Public Administrations of distributed registration technologies, including blockchain.

### Education

Spanish education is at a critical moment as it has the second highest early school leaving rate in Europe (18.3%), more than 7 points higher than the European average (10.6%), according to the data published by Eurostat in May 2017<sup>62</sup>.

In this context, RDI can contribute to the development of the technologies on which AI is based. It can improve learning and modernize our country's education and training systems, presenting itself as a new opportunity to solve old and new challenges in Education. The use of intelligent systems would make it possible to transform Spanish education from different technologies, guaranteeing inclusive, renewed and adapted training to the needs of students and teachers according to the preferences, knowledge and individual evolution of the student.

Its large-scale implementation could completely transform current education. The key aspect is that AI techniques enable the application of new educational models oriented to personalised learning. Firstly, students would play a more active role in their learning process by knowing their own evolution and being more aware of how to optimise it. Secondly, it would allow educational and training centres to identify those students who require more support<sup>63</sup>.

<sup>58</sup> [https://www2.deloitte.com/insights/us/en/focus/cognitive-technologies/artificial-intelligence-government.html?icid=dcom\\_promo\\_featured|t:en](https://www2.deloitte.com/insights/us/en/focus/cognitive-technologies/artificial-intelligence-government.html?icid=dcom_promo_featured|t:en)

<sup>59</sup> A national security strategy must comply with the objectives of the security policy, which ensure the protection of national interests. This type of strategy is applied both in times of peace and in times of war and has as its limits the general policy (upper limit) and the departmental strategies of the governments (lower limit).

<sup>60</sup> <https://cordis.europa.eu/project/rcn/203297/factsheet/en> (ASGARD).

<sup>61</sup> Percentage of young people aged 18 to 24 who have dropped out of school with a degree lower than post-compulsory secondary degree  
<http://estadisticas.mecd.gob.es/EducaJaxiPx/Datos.htm?path=/Formacionyml/EPA2016/Aban/10/&file=Aban102.px&type=pcaxis>

This analysis would make it possible to improve measures and strategies for talent retention and empowerment. Aspects such as the evaluation and identification of high competences in students (**AI predictive models**), the treatment of students with functional diversity (learning analytics, adapted AI-based systems), new tutoring models (**intelligent tutoring systems**), **recommendation** and feedback systems; prediction of early failure and detection of abnormal students through **machine learning** systems and the evaluation of competences could be addressed.

Of course, these benefits are not risk-free and require proper application. To this end, we need teachers trained in digital competences and ethical treatment of the data analyzed (see Priorities 4 and 6).

### Smart and sustainable cities and territories

Smart Cities and Territories are one of the most important developments to which AI will contribute and which will have a direct impact on national economies. AI can help to design and build sustainable cities, through the use of autonomous and connected ecological vehicles (reflected in the Industry 4.0 area); applications that contribute to improve and make mobility safer<sup>64</sup>; or make transport connectivity more efficient; improve the sustainability of cities from the point of view of energy, welfare and equal opportunities.

For example, AI technologies should contribute to the development of artificial sensor capabilities (induction loop detectors, video cameras, microwave sensors), smart electrification of cities, public transport scheduling, optimal routing of vehicles and pedestrians, dynamic adjustment of speed limits and traffic regulation devices, life cycle optimization of buildings through construction modeling technology (BIM) hybridized with AI technologies, as well as city management based on evidence and scenarios thanks to predictive and prescriptive data analytics. Among the different relevant AI technologies we will highlight **deep learning**, intelligent traffic systems, **multimodal planning algorithms** and **multi-criteria optimization**.

### Health

Health care is seen as a sector that would benefit greatly from AI and is one of the key focus areas of the AI's Coordinated Plan.

The AI will save billions<sup>65</sup> of Euros by improving the prevention, diagnosis and treatment of childhood obesity, cardiovascular diseases and their sequels, neurodegenerative diseases and breast cancer, among other areas. In addition, it will make it possible to develop new medicines and promote personalised and home-based medicine or improve the quality of life of the elder.

The Spanish Government's budget for health policies for 2018 amounted to 4,251 million Euros, an increase of 3.9% over the previous year, representing 6.3% of the national GDP. It is expected that this increase will continue to occur in the coming years, since according to a recent study<sup>66</sup>, Spaniards will have the highest life expectancy in 2040.

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<sup>62</sup> V.A. Romero-Zaldivar, A. Pardo, D. Burgos, C.D. Kloos (2012). Monitoring student progress using virtual applInces: A case study. Computers & Education, 58 (4), 1058-1067.

<sup>63</sup> [https://ec.europa.eu/transport/road\\_safety/sites/roadsafety/files/pdf/statistics/dacota/asr2017.pdf](https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/asr2017.pdf)

<sup>64</sup> <https://www.pwc.de/de/gesundheitswesen-und-pharma/studie-sherlock-in-health.pdf>

In this context it is necessary to have an AI capable of explaining to medical professionals the reason for their decisions, improving the methods of person-computer interaction. At present, doctors rely on their experience when making the most probable diagnosis. An automatic assistance, capable of carrying out these probability calculations in a normative way and with real time access to the necessary data from the scientific literature, would allow a greater productivity of the health professionals. One of the challenges in this regard is to train a new generation of more technological doctors capable of helping in the design of these cognitive assistants.

The so-called "P4 Medicine" (predictive, personalized, preventive and participatory), will be based on emerging technologies such as AI and the **Big data analysis** based on automatic learning and computer vision. Thus, data science will be routinely applied to structured and unstructured information from electronic health records, omics (genomics, proteomics, transcriptomics, etc.) and medical imaging tools.

## AI FOR THE ECONOMY

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### Connected Industry 4.0

The connected Industry 4.0 concept<sup>67</sup>, consists of the massive introduction of digital technologies that, beyond automation, have a transforming effect in their processes, operations, products and services, as well as in the productivity of the employees and in the business models of manufacturing sectors. Spanish industry represents 13% (of the manufacturing industry)<sup>68</sup> of the country's added value and employs 11% of the employed population<sup>69</sup>, so the social and economic impact of AI technologies is essential.

To achieve a smart industry means to achieve a significant advance within the areas that include the operation and intelligent maintenance, thanks to an advanced management and analysis of massive data coming from the operation and maintenance of the assets of the industry and thus to improve its operational performance. Noteworthy are models for industrial diagnosis and prognosis of failures in equipment, components and systems in service, as well as models capable of estimating, preserving or extending the functional useful life of industrial assets during their design and operation phases.

Achieving **advanced** robotics, beyond automation, with increasing levels of perception, coordination, collaboration and intelligence by creating human-robot hybrid contexts. The challenge is to empower machines and robots to adapt in real time to changes in products and processes, with the ability to **learn by experience or** mimic behaviour through **learning by imitation**. This advance requires key aspects: **perception and understanding; autonomous planning** of movements and actions and; **adaptation** of the action in interactive mode with humans or **swarm models**.

AI architectures and models that support assets, processes, industrial environments, supply chains and delivery of goods or services that require a high level of digitization are needed. For example, the architectures of ingest, processing and **high-performance analysis data**, the concept of digital twin applied to an industrial asset, hybrid models that complement other legacy technological approaches, and those that allow typical industrial data limitations to be overcome.

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<sup>65</sup> Kyle J Foreman et al. (2018). Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: reference and alternative scenarios for 2016–40 for 195 countries and territories. *The Lancet*, 352, 2052-2090

<sup>66</sup> <http://www.industrAlconectada40.gob.es>

<sup>67</sup> <http://www.ine.es/jaxi/Datos.htm?path=/t35/p010/base2010/I0/&file=01001.px>

<sup>68</sup> Contabilidad Nacional de España. [http://www.ine.es/dynqs/INEbase/es/categorAI.htm?c=Estadistica\\_P&cid=1254735576581](http://www.ine.es/dynqs/INEbase/es/categorAI.htm?c=Estadistica_P&cid=1254735576581)



Improving the operational performance of people in the plant as well as their degree of assimilation with respect to new technologies. Advances based on RDI should assist industrial plant operators, specifically in hostile environments, optimizing intra-logistic flow planning and production line performance under different criteria. It is also necessary to review the integrated AI in work elements (devices) to increase the safety of operators in confined spaces to avoid collisions or security breaches.

Today, one of the industrial sectors that is most affected by IA technologies is the automotive industry. It should be noted that the RDI of autonomous vehicles began in 1987 with the European EUREKA Prometheus project<sup>70</sup>. Spain is the ninth largest producer of cars and light commercial vehicles, with nearly three million units produced in 2018<sup>71</sup>. The 17 Spanish factories generate around 250,000 direct jobs and nearly two million indirect jobs, with a 10% share of GDP<sup>72</sup>. The importance of this sector goes beyond the just industrial. These economic and social aspects, added to the need to converge towards a new urban organization more efficient in the displacement, force the development of autonomous transport systems that directly and indirectly will have a great influence in the day to day of a great part of the society. The development of **new driver assistance technologies** to supply the human driver requires the generation and application of new knowledge about AI and its consideration of ethical aspects, with the ultimate aim of improving safety, comfort and reducing costs.

The development of new technologies and more accurate sensors (GPS, gyroscopes, accelerometers, ambient light sensors, humidity sensors and others) are necessary to supply the human driver, improve safety, comfort and reduce costs. The new sensors will provide the availability of data and connectivity in transport, fundamental aspects for the development of **intelligent traffic prediction systems**, route calculation and shared UPS, which will transform transport as we know it today. It is important to emphasize that the autonomous vehicle as a means of transport of people or things transcends the terrestrial environment, being IA a key factor for the development of the industries in other means like the air (drones) or the marine (autonomous ships).

### Natural Resources, Energy and Environment

The challenge of using AI in environmental applications will contribute to the Circular Economy and ensure an AI that respects the Earth<sup>73</sup>. As the scale and urgency of human health and economic impacts due to the deterioration of our natural environment increases, there is an opportunity to see how AI can help transform industry sectors and traditional production systems to cope with climate change, provide food security and increase water quality, help design and help ensure and protect biodiversity and, by extension, human well-being.

One area specially relevant to our country is agriculture. In 2018, the value of agri-food exports in Spain, together with their related activities, was 50,348 million Euros, representing 17.6% of total Spanish exports<sup>74</sup>. Therefore, this sector is fundamental for the country's competitiveness. In this primary sector, the widest application of AI, favouring synergies between IA research groups and sustainable agriculture groups is presumed to be in place. Examples of this interaction are intelligent methods for sustainable and ecological agriculture and food production systems.

The use of AI techniques, in particular **automatic learning** with big data and predictive analysis, improve precision agriculture in each link of the agricultural chain with individualized land management in real time (irrigation, phytosanitary treatments and subsequent harvesting and transformation<sup>75</sup>). When it comes to sustainability, AI can help drastically reduce the consumption of resources such as water, or the use of better observation and automatic learning systems that can reduce the use of plant protection products by up to 90%, something that is possible thanks to automatic learning that optimises the spraying of the plant on site<sup>76</sup>.

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<sup>69</sup> [https://en.wikipedia.org/wiki/Eureka\\_Prometheus\\_Project](https://en.wikipedia.org/wiki/Eureka_Prometheus_Project)

<sup>70</sup> <http://www.oica.net/category/production-statistics/2017-statistics/>

<sup>71</sup> <http://www.investinspain.org/invest/es/sectores/automocion/descrpcion/index.html>

<sup>72</sup> <https://www.weforum.org/projects/fourth-industrAll-revolution-and-environment-the-stanford-dAllogues>

<sup>73</sup> [https://www.mapa.gob.es/es/ministerio/servicios/analisis-y-prospectiva/completo2017mapa\\_tcm30-457793.pdf](https://www.mapa.gob.es/es/ministerio/servicios/analisis-y-prospectiva/completo2017mapa_tcm30-457793.pdf)

The impact of external factors on these resources can be predicted and measured through **intelligent weather and climate prediction systems** and intelligent systems for early response to natural disasters. In the energy sector, AI contributes to efficiency through **multi-agent** systems in intelligent energy distribution grids and applications or **agent-based modeling** for energy sustainability.

## Safety

In today's globalized world where threats to security are a major source of concern in our society, both from cybersecurity (Internet and the Internet of things) and from physical security, RDI in AI technologies dedicated to cybersecurity systems to detect and repel threats, through **language technologies**, **image analysis** and **automatic learning**, is considered key.

It should be noted that automated attacks and so-called "advanced and persistent threats" (APT) carried out by AI systems require developments provided by equally advanced defense systems in AI capabilities. The urban environment poses major challenges related to citizen security, protection, and prevention and control of crime, which vary between different areas of a city depending on their particular economic and social conditions. A 2017 Eurostat report<sup>77</sup> stated that the subjective perception of a threat and the consequent feelings of insecurity that undermine the quality of life should be one of the indicators used to measure the quality of life.

Crowds gathered at large events or in transport hubs present a new type of challenge in which safety guidelines<sup>78</sup> are indispensable. AI-based tools must develop systems capable of monitoring in real time large amounts of data obtained from the network, and perform **analysis of security camera images** in real time, allowing the detection of attacks on the security of society and businesses.

The current algorithms are still deficient, although it is hoped that in the future they will improve their predictive capabilities: the **analysis of images** from video cameras or the analysis of social networks with **language technologies** and the design of profiles based on the analysis of **temporal sequences of data**, should avoid the detection of false positives. These are areas in which progress must be made to predict behaviour and potential incidents while respecting the ethical issues they raise.

The field of security includes other fields such as the aspect of assistance to groups at risk of exclusion. AI can intervene to improve the safety of these groups through the analysis of **social patterns for prevention**.

Another essential element that is linked to the development of the transport industry is safety. In 2017 there were 1,943 deaths in Spain as a result of traffic accidents (INE data, 2019). In 2015, traffic accidents in the EU resulted in the loss of 26,100 lives and the injury of more than 1.4 million people<sup>79</sup>. This social aspect is linked to the new technologies, to greater precision in the sensors, as well as to the **intelligent traffic prediction systems**.

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<sup>74</sup> <http://observatorio-AI.com/agricultura-de-precision-i-a>

<sup>76</sup> <http://www.AIs.csic.es/>

<sup>77</sup> Final report of the expert group on quality of life indicators <https://ec.europa.eu/eurostat/documents/7870049/7960327/KS-FT-17-004-EN-N.pdf>

<sup>78</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/701910/170614\\_crowded-places-guidance\\_v1a.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/701910/170614_crowded-places-guidance_v1a.pdf)

## Tourism and creative, cultural and AI-based experience industries

Technology in tourism is of vital importance in the national economy since through its use, companies can increase their productivity and better promote their goods and services, with opportunities and facilities for both the client and the tourism industry. In Spain, tourism is one of the axes to enhance in a profound transformation of the economy towards digitalization. Tourism is one of our strategic sectors: in 2017 Spain generated 11.7% of the national GDP<sup>80</sup>. But being able to maintain these results depends, to a large extent, on the sector's capacity to face the challenges that arise, which from an IT point of view are the new digital environments (in which cybersecurity or Big data are key), the evolution of marketing and sales with online tools, or the new reputation in a connected world.

Social networks have significantly changed our consumption habits. That is why there are several important aspects in this new 4.0 Hospitality that must be addressed from the point of view of R & D, such as: the area of recommender systems, or the construction of personalized guides, and tools that allow a customization of the experience to the personal tastes of tourists, their purchasing power, their education, their origin, their personal needs, etc. and can be extended to other areas of leisure, such as concerts, theater or sporting events, for example.

Likewise, AI as an enabling technology allows the digitization, analysis and interpretation of massive sources of socio-economic, economic, political, cultural and heritage data. The infrastructures of massive digitization of historical and cultural heritage and high-performance computing are complemented with AI technologies for the treatment in digital space of the objects of the humanities, generating a radical change in research procedures. It is worth highlighting, specifically, the analysis of the vast and rich historical and cultural heritage as one of the most important assets of the country. IA is transforming the methods and processes for the conservation of and access to this generally *hidden* heritage in archives, libraries and museums. AI provides innovative ways to access, experience and disseminate digital heritage not only to the academic community but also to the general public with tools, such as automatic learning, that enable (re)interpretation of the past and decisions about the present and the future. As an example, we can cite the new open data portal of the National Library of Spain<sup>81</sup>. In short, the IA applied to the humanities is generating new models and services with an important impact on tourism, culture or education, as well as on policy making, urban planning and environmental, economic and social modelling, among other areas.

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<sup>79</sup> [https://ec.europa.eu/transport/road\\_safety/sites/roadsafety/files/pdf/statistics/dacota/asr2017.pdf](https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/asr2017.pdf)

<sup>80</sup> [https://www.ine.es/jaxi/Datos.htm?path=/t35/p011/base\\_2010/serie/i0/&file=01001.px](https://www.ine.es/jaxi/Datos.htm?path=/t35/p011/base_2010/serie/i0/&file=01001.px)

<sup>81</sup> <http://datos.bne.es/inicio.html>

### PRIORITY3. DEFINE AND DEVELOP ACTIONS THAT ALLOW THE TRANSFER OF KNOWLEDGE

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#### PRIORITY 3

Maintain the line of good practices: Public-private collaboration in mixed technological ecosystems and calls for PCIs addressed to the AI

*Coordination between the Network of Nodes and Centres of Excellence and DHI*

Create a computer platform where RDI agents can experiment with their developments before launching them on the market

Training tools aimed at AI skills and certifications

Analyze/promote the use of the financing tools of the State RDI Plan for the promotion of knowledge transfer by making them more dynamic.

The transfer of knowledge between RDI sectors (universities and research centres) and companies is essential for the improvement of production processes, the improvement of public services, and for economic and social improvement through new innovation and business opportunities.

As mentioned in Priority 1, traditionally, the transfer of knowledge from the university to companies has been understood in the context of public-private collaboration projects and through the different collaboration instruments (EBT company, centres or units formed by R&D departments of companies and research structures of research organizations, among others). There are examples of good practices such as: mixed technological ecosystems formed by companies and Universities, such as the Joint Technology Centre in AI (Innovation Space<sup>82</sup>) and public-private associations that participate in calls for Innovative Public Procurement, as is the case of the calls for Innovative Public Procurement in the Language Technologies Promotion Plan of the Digital Agenda<sup>83</sup>.

The different **collaboration structures** together with the Network of Nodes and Centres of Excellence and DIHs should be coordinated and contribute to the development of an RDI ecosystem that brings innovations and benefits to the value chain and improves the country's Welfare State.

To achieve this objective, instruments and actors must be properly financed and supported through the tools available in both the public and private sectors, creating opportunities that must be exploited both in terms of investment and regulation. On the other hand, the rapid evolution of the AI market and its ecosystem requires new specific actions aimed at the transfer of knowledge based on the development of AI technologies, turning these technologies and their transfer into a first class strategic activity in Spain. All of this should contribute to creating new opportunities to promote the aforementioned RDI ecosystem in AI.

These actions, as facilitating elements of the transfer of knowledge of AI, could include, but are not intended to be exhaustive, the following:

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<sup>82</sup> <https://www.ainnovation.upm.es/>

<sup>83</sup> <http://www.agendadigital.gob.es/tecnologAls-lenguaje/Paginas/plan-impulso-tecnologAls-lenguaje.aspx>

- The **creation of a platform and a computer ecosystem** where universities, science and technology centres and national SMEs can experiment with their innovative developments before launching them on the market. This platform should act as a one-stop shop, providing and displaying services, expertise, certified algorithms, programming models, development tools, components, modules, unbiased databases, computing resources, prototyping functions and access to public and private finance.
- As stated in Priority 1, the transfer of knowledge between science and technology centres and companies with greater agility in collaboration with DHI should be encouraged through these IHL-specific technological innovation consortia.
- To offer **training tools** allowing different user communities to obtain skills and certifications in the area of AI.
- Existing instruments should be analysed and, where appropriate, adapted by making them more dynamic in the different programmes of the State Plans in order to optimise the transfer of IA knowledge.
- Use the available tools of the PECTI as:
  - The IA call for **Innovative Public Procurement** projects in AI with the aim of boosting the Spanish market and improving the provision of public services, both in the pre-commercial public procurement modality and in the public procurement of innovative technology.
  - CDTI's INNVIERTE Public Venture Capital programme<sup>84</sup>.
  - Enhance current public-private collaboration tools focused on the area of AI.
  - Analyze the design of evaluation commissions in the different project calls for proposals with the aim of paying specific attention to AI.
  - The promotion of industrial doctorates<sup>85</sup> in the field of AI and the creation of AI startups from university environments on the basis of the results obtained by RDI financed by the administration.
  - To value positively in the State Program for the Promotion of Talent and its Employability in RDI the post-doctoral experience in the development of AI projects with companies and the transfer of knowledge to the socio-economic sector.

#### **PRIORITY 4. DEVELOP A SYSTEM TO PROMOTE CROSS-DISCIPLINARY AND VOCATIONAL TRAINING IN ARTIFICABLE INTELLIGENTSIA**

##### **PRIORITY 4**

RDI is responsible for participating in educational transformation and responding to the need for transversal and specific training following the developments of AI technologies.

This adaptation of training should be extended to professional training methodologies in a context of lifelong and accessible learning.

<sup>84</sup> The INNVIERTE programme is part of the Spanish Science and Technology and Innovation Strategy 2013-2020. This initiative does not form part of the PECTI grants but has a strategic role in the development and consolidation of venture capital funds in all their phases, including seed capital and equity funds co-participated by public entities that, like INNVIERTE, support innovative companies with a high growth potential in strategic sectors for the Spanish economy. INNVIERTE seeks to promote business innovation by supporting venture capital investment in TBCs or innovators, favouring the creation of a specific ecosystem that not only covers the financing of the different phases of the life cycle of companies, but also supports their management needs, technology knowledge and access to international leaders.

<sup>85</sup> <http://www.ciencAI.gob.es/portal/site/MICINN/menuitem.dbc68b34d11ccb5d52feb801432ea0/?vgnextoid=2e6be8ade1e01610VgnVCM1000001d04140aRCRD>

One of the biggest problems faced by the development of AI in Europe is the shortage of experts. Identified as a strategic area in this document, the emergence of AI requires an education adapted to the digital society in which we find ourselves, as well as the necessary training in digital competences in our educational and labour system. The more we delegate to machines, the more responsibility and training we must demand of their designers. This educational transformation implies the need for **transversal and specific training** in subjects related to IA both for the development of talent in professionals in the area and for the need to update the knowledge of society in general. It is essential for citizens to be aware of the disruption caused by the digital transformation and massive application of AI. In order for citizens to understand the implications of the use of IA and technology and to maximize the opportunities it brings, it is necessary for them to have the competence to relate to IA and its different fields of action.

In France for example, it is estimated that over the next three years it is essential to multiply by three the number of professionals trained in IA both at University level (Degree, Master, Doctorate) and Professional Training<sup>86</sup>. The need to increase the number of professionals researching in IA is also reflected in other national strategic plans such as the German Plan, with the creation of one hundred new chairs and actions aimed at recovering and retaining talent and incorporating new talent into a competitive environment.

In order to face this objective, R&D plays a fundamental role in the adaptation of the Spanish educational system to this new technological reality. It is necessary to adapt the educational model following in the wake of the developments of the most advanced technologies of AI, contemplating the formative hybridization of sciences, technologies and humanities and training to think and act and not just to know. These concepts should be present in a large number of university degrees, specifically, but not only in those linked to programming, science, technology, engineering and mathematics (the so-called STEM studies), as well as at previous levels and in continuing education. According to the EU Country Report 2019<sup>87</sup>, levels of basic and advanced digital skills remain below the EU average although the number of graduates in science, technology, engineering and mathematics (STEM) is increasing (21 higher education graduates per thousand inhabitants aged 20 to 29, compared to 19 in the EU, but with a significant gender gap). Information and communication technology specialists still account for a low proportion of the workforce (3% compared to 3.7% in the EU). This educational process should be approached from an even broader perspective than STEM studies, moving on to STEAM studies, which add creativity to the corpus of knowledge through the Arts and Humanities, since without creative thinking scientific-technological progress is slower. Large technology companies such as Alí Baba, Facebook and Google are already applying this model, creating multidisciplinary teams that have led to an increase in the hiring of professionals with a humanistic profile<sup>88</sup>.

For the transformation of an important number of current positions due to the implementation of AI technologies, we must promote continuous training throughout professional life. Professionals in areas such as economics, law, engineering or medicine, among others, should be able to understand and use these technologies as needed. The role of RDI will be essential in the process of reflecting on, **reformulating and promoting educational** programs of different types, such as specific degrees and postgraduate courses, but also specialization courses and high quality MOOC courses (open-ended online courses) that will allow us to respond to the competences required by future professions.

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<sup>86</sup> Villani, C. (2018). For Meaningful Artificial Intelligence. Towards a French and European Strategy. [https://www.aiforhumanity.fr/pdfs/MissionVillani\\_Report\\_ENG-VF.pdf](https://www.aiforhumanity.fr/pdfs/MissionVillani_Report_ENG-VF.pdf)

<sup>87</sup> [https://ec.europa.eu/info/publications\\_en](https://ec.europa.eu/info/publications_en)

<sup>88</sup> <https://riipen.com/2018/01/11/beyond-boundaries-why-the-arts-and-humanities-are-needed-in-a-stem-dominant-world/>

### PRIORITY 5

AI technologies are essential in the development and implementation of a digital infrastructure aimed at storing and providing access to the data generated in RDI projects financed by the Public Administrations.

These infrastructures must be aligned at European level with the EOSC.

The SECTI legal and strategic framework should develop and implement a one hour roadmap for these digital infrastructures.

Digital RDI data infrastructures should converge with the RISP sector at national level which should encourage the incorporation of private data.

The AI RDI Strategy recognizes the essential value of data in the development of AI. Data is classified in many ways: according to its size (small, medium or big data), quality or origin (from research projects, generated by the Public Administration, mobile devices, sensors, programs, whether public or private, by citizens, etc.). The data are in multiple formats (structured, semi-structured and unstructured), in a multitude of domains and languages, affecting or not the privacy of the individual and with different policies or licenses of use (open, closed, conditional access depending on whether certain requirements are met, etc.).

Any institution (public or private) that decides to manage, reuse and exploit its data with IA techniques needs an organizational structure, a digital and legal ecosystem, that certifies the entire life cycle of the data, and that goes beyond the data itself and the physical platform that houses it. Additionally, the management of open data from Administrations requires transparency in the planning, governance, implementation and maintenance of the processes and procedures that generate data, the physical infrastructures and the processes and applications that use it for specific purposes, including, among others, the following functions:

1. Transparency and certification of the governance of the entire digital ecosystem;
2. Certification processes throughout the data life cycle, specifically when. (i) the open data is "delivered" to a third party for use and exploitation, or (ii) a citizen, company or software system wishes to verify whether an Administration data provided by a third party is correct and up to date. The purpose is to avoid spam in data or fake data from public sector data<sup>89</sup>.
3. Definition of a quality management system for the processes and products (datasets) generated;
4. Catalogue of permanently updated data (open and closed) that satisfy the quality criteria;
5. Provide good practices and technologies that automate the opening, management, reuse and exploitation of public sector data by the Administration or by third parties.
6. Provide the computational physical infrastructure that allows the storage of data sets throughout their life cycle and their associated metadata;
7. Manage privacy and security policies;
8. Provide AI algorithms and software platforms that provide a wide range of common and **frequently used services during the data life cycle** (acquisition, curing, integration, storage, downloading in different formats, application programming interface consultation, validation; and other no less relevant navigation, visualization and certification services that generate confidence in users) and others of added value.

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<sup>89</sup> <https://ec.europa.eu/digital-single-market/en/news/final-report-high-level-expert-group-fake-news-and-online-disinformation>

The State Plan for Scientific and Technical Research and Innovation 2017-2020 set itself the objective, through the actions it finances, of promoting open access to publicly-funded research results and data, as well as promoting a research model that is responsible and open to society and that allows the reuse and exchange of research data. In this respect, it is essential to respect and make compatible with the assumptions of industrial secret protection, patents, industrial design, etc. As with RISP data, research data are digital infrastructure<sup>90</sup>. In addition, this set of data would be enriched with those that could be provided by private entities, for which it is necessary to explore the definition of incentives for these private entities to form part of the data infrastructure.

To build this digital infrastructure, Spain has a set of public research infrastructures of European stature that facilitate the development of research in the area of IA and are poles for attracting talent and investment. This set of world-class **physical computing infrastructures** allows the exploitation of IA technologies through a very high power of calculation and data storage, collection and distribution. The Spanish Supercomputing Network (RES)<sup>91,92</sup> is a distributed infrastructure consisting of the interconnection of thirteen supercomputers in order to offer high-performance computing resources to the scientific community. Of note is the *MareNostrum 4* supercomputer from the National Supercomputing Center/Barcelona Supercomputing Center (BSC) coordinated by the RES.

Spain is actively involved with the European Commission in promoting the design of a European Scientific Data Cloud (EOSC) that will set up a federated system to store, share and reuse in an interdisciplinary way the data generated in scientific and innovation projects financed with public funds, using quality standards, certification and common rules of participation. Our country has **to define the roadmap for the implementation of EOSC** under the current regulatory framework of Law 14/2011 of the Science, Technology and Innovation, the EECTI and the main instruments to develop the policy of open science. This new framework offers the scientific and academic community related to IA a new perspective for the distribution and use of their data.

This initiative of the Spanish scientific community must **converge with the development of the Reuse of Public Sector Information sector**<sup>93</sup> (RISP, also known as open data) in Spain. The RISP sector has been broad in the context of the National Government, regional and local administration, with normative development in the form of laws, royal decrees and technical standards and which have led to technological and organisational changes within their own organisations and has enabled Spain to position itself at the top of the world in the area of open data, according to the latest world-wide barometers<sup>94</sup>. The Government of Spain's open data initiative **datos.gob.es**<sup>95</sup> provides open data sets, in a data catalogue that is still incomplete as there are more open data than those entered in the catalogue. On the other hand, an economy based on the use and analysis of data should contemplate the inclusion of private data with different types of licenses.

Examples of application of IA techniques to open PPPA data are the exploitation of mobility data<sup>96</sup>; the exploitation of public procurement data<sup>97</sup>; or the exploitation of tourism data. Some of the services identified in the blueprint on Government for 2030 of the European CLARITY<sup>98</sup> project require the use of these techniques: personalisation of services, universal access services, ubiquitous, user-centred design.

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<sup>90</sup> <https://www.openaire.eu/>

<sup>91</sup> <http://www.ciencAI.gob.es/portal/site/MICINN/menuitem.eed4570ef37d2c8fbaa777b9026041a0/?vqnextoid=928d5ef3677c4610VqnVCM1000001d04140aRCRD>

<sup>92</sup> <https://www.res.es/>

<sup>93</sup> [https://administracionelectronica.gob.es/pae/Home/pae\\_EstrategAI/pae\\_Gobierno\\_Abierto\\_Inicio/pae\\_Reutilizacion\\_de\\_la\\_informacion\\_en\\_el\\_sector\\_publico.html#.XFQgoFX0m7Q](https://administracionelectronica.gob.es/pae/Home/pae_EstrategAI/pae_Gobierno_Abierto_Inicio/pae_Reutilizacion_de_la_informacion_en_el_sector_publico.html#.XFQgoFX0m7Q)

<sup>94</sup> <https://opendatabarometer.org/>

<sup>95</sup> <http://datos.gob.es/>

<sup>96</sup> <https://datos.gob.es/es/noticia/2019-el-ano-de-los-datos-abiertos-de-transporte-publico-en-espana>



In short, Spain should **encourage the creation of a digital infrastructure associated with AI**, not necessarily centralized, but distributed and providing the different components of the infrastructure, specifically data sets, certifications of processes and stored data, commonly used AI algorithms and computational physical infrastructures that can be included in pan-European infrastructures.

Finally, Spain's privileged position in the deployment of very high-speed connectivity, lever for digital transformation and the adoption of AI. Spain already has the most extensive fiber optic network in Europe covering more than 76% of the population, but it must continue to promote the deployment of connectivity infrastructures as a factor of inclusion so that AI can be adopted by all companies, citizens regardless of their geographical location. The implementation of the National Broadband Extension Program (PEBA) and the National 5G Plan need to be reinforced and deepened.

## **PRIORITY 6: ANALYZE THE ETHICS OF AI FROM THE PERSPECTIVE OF RDI**

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### **PRIORITY 6**

Developments in AI technologies should avoid negative bias and gender bias or other forms of discrimination.

The Spanish Committee on Research Ethics should lead the activities of analysis and assessment of the ethical aspects of the use and implementation of AI in the activities developed in the State RDI Plans.

Approach, from a multidisciplinary vision, the general design of AI systems from an alignment of ethical, legal and social aspects

Contribute from RDI in the drafting of a Code of Ethics for AI

There are many ethical questions surrounding the role that AI plays or has to play in society, in employment or its impact on the economy. The success of AI will depend on how people and machines work together to provide better services - transparent, reasonable and ethical - to potential users, in a world where we will be increasingly demanding in terms of the quality of services provided. It is a condition in the development of technologies and applications of AI linked to this RDI Strategy **to avoid the negative bias** and prejudices of our society, such as gender, race, or other forms of discrimination, which must be avoided by decision support systems.

From a European point of view<sup>99</sup>, and as the AI HLEG<sup>100</sup> states, a reliable and ethical AI, made in Europe, has to be built on the basis of decades of consensual application of fundamental rights in the EU, in a way that provides clarity, readability and foresight for users, investors and innovators. This requires an adapted legal framework for the IA to be used in a fair, transparent and accountable manner, and to address the multicultural nature of Europe; to combat unintended biases and to ensure that social and economic concerns related to job loss, unfair competition or possible domination of machines are adequately addressed.

<sup>97</sup> [www.theybuyforyou.eu](http://www.theybuyforyou.eu)

<sup>98</sup> <http://www.zaragoza.es/sede/portal/clarity/index>

<sup>99</sup> [https://ec.europa.eu/newsroom/dae/document.cfm?doc\\_id=56433](https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=56433)

<sup>100</sup> <https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence>

In Spain, interest in the ethical uses of AI is not a new discussion, but it has often been confined to academic settings. In March 2017 these discussions leapt into the public arena with the holding of a pan-European symposium the most important outcome of which is a manifesto known as the "Barcelona Declaration on the Development and Appropriate Use of AI"<sup>101</sup>. The declaration considers eight points - many of them common to similar manifestos produced in other parts of the world<sup>102,103,104</sup> and which summarize the European ethical tradition and scientific thinking on which research in the discipline has been founded in Europe, be it knowledge-based AI or that based on intensive and extensive data processing in Europe. Among these points, it should be noted that AI applications must be prudent, reliable, responsible, identifiable, with autonomy governed by a set of rules that safeguard the human heritage.

The ethics of RDI applied to AI is a transversal priority as we have seen throughout this RDI Strategy. It is therefore necessary to make an additional effort through fundamental research to determine how to design better AI systems that incorporate ethical reasoning. Spain, through the different agents of the SECTI and, with the outstanding role of the CEEI as an independent and consultative body on materials related to professional ethics in scientific and technical research, must be active in these aspects of definition and identification of AI at national and European level including the analysis and proposal of indicators that help to measure the effectiveness of the measures included in the PECTI. The Committee should assess and advise on the use and implementation of the IA to help the agents of the SECTI, as well as society in general, and in a way that allows to establish an ethical position on the advances of AI in accordance with the European alignments. The work of the CEEI may be accompanied by international cooperation with the aim of drafting an AI Code of Ethics aligned with the efforts made by the European Commission in this regard<sup>105</sup>.

In this priority, the ultimate objective of the Spanish scientific community will be to approach, from a multidisciplinary viewpoint, the general design of AI systems from an alignment of ethical, legal and social aspects.

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<sup>101</sup> <https://content.iospress.com/journals/ai-communications/31/6>

<sup>102</sup> <https://futureoflife.org/ai-principles/?cn-reloaded=1>

<sup>103</sup> [https://obamawhitehouse.archives.gov/sites/default/files/whitehouse\\_files/microsites/ostp/NSTC/preparing\\_for\\_the\\_future\\_of\\_ai.pdf](https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf)

<sup>104</sup> <https://www.accessnow.org/the-toronto-declaration-protecting-the-rights-to-equality-and-non-discrimination-in-machine-learning-systems/>

<sup>105</sup> <https://ec.europa.eu/digital-single-market/en/news/draft-ethics-guidelines-trustworthy-ai>



**RECOMMENDATIONS**

The following **Recommendations** transcend the scope of RDI in Spain and also call for the presence of other sectors and ministerial departments. Due to the multidisciplinary and transverse nature of AI and the aforementioned technological and social revolution that it entails, it would be logical to align the different sectorial Strategies of the State and the existing initiatives and instruments. This coordination and co-development work must be taken into account when drawing up the IA National Strategy and the State and Action Plans developed to implement public policies based on the AI Inter-ministerial Working Group created on 28 December by the Delegate Commission for Scientific, Technological and Innovation Policy.

### **RECOMMENDATION 1: LAUNCH A NATIONAL STRATEGY FOR AI**

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On December 28, 2018, the Delegate Commission for Scientific, Technological and Innovation Policy agreed on the creation of an **Inter-ministerial Working Group on AI** that will respond to AI as the strategic axis of Spanish society in the 21st century and that will involve the competent Administrations. This AI RDI Strategy should serve as the basis for the necessary work between the different Ministries in this Group, which will allow the launch of a **National AI Strategy** that includes areas beyond RDI, which will certainly be altered by the entry of IA into society such as the labour market, the educational model, the legislation in force and the relations within the society itself with the new services and systems developed. This national framework should include the sector areas identified in the Spanish RDI strategy in AI and, if necessary, identify other areas considered necessary to have a significant impact on the challenges of our social and economic environment. Finally, it is important to highlight the importance of evaluating the impact of financing and its activities derived from this strategic framework. The evaluation and monitoring of this National Strategy may be carried out through a **Spanish AI Observatory** with the participation of the organizations that form part of the Inter-ministerial Working Group and other public and private socio-economic agents.

### **RECOMMENDATION 2: AI VALUE TO REACH THE ODS SET BY THE AGENDA 2030**

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The preliminary analysis of the strategic areas affected by AI from an RDI viewpoint demonstrates a clear correspondence with the Sustainable Development Objectives included in **Agenda 2030** and reminds us of the need to align both policies and State interests. This global approach implies, with the **RDI Strategy in AI**, taking the first step in the development of the national strategic framework that makes IA a lever technology or a transformer of public policies. It is this leverage action that should facilitate, through the different strategic actions or state plans in the different sectors of action of the Administration, to achieve the maximum positive impact on society taking care of its effect on the labour market, the adaptations at educational level and its impact on current legislation.

### **RECOMMENDATION 3: IMPACT THE SOCIAL AND ECONOMIC FABRIC WITH AI**

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The AI market is in continuous evolution and presents great opportunities for private investment, but it must also be the object of interest on the part of public entities to empower it and make it competitive, both in terms of investment and in terms of regulation. We are in a new context, both because of the transformation of our society with AI and because of the **new ways of transferring knowledge**, which must be exploited for a new competitive advantage, opening up a new space for collaboration not only between research centres and universities but also with SMEs, large companies, social partners and other agents in the socio-economic fabric, in keeping with the new innovation models. For this reason, specific actions are needed to promote the transfer of knowledge that will enable Spain to create this competitive advantage, taking advantage of the possibilities it offers and so as not to lose this opportunity for development led by China and the United States.

## RECOMMENDATION 4: INCLUDE THE KNOWLEDGE AND USE OF AI IN THE LABOUR MARKET AND THE PROMOTION, RECOVERY AND ATTRACTION OF TALENT

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It would be desirable to have a **program to promote AI vocations**, according to the demand of the labour market, with specific attention to gender equality, which is currently a major gap. There is also a specific mention of **attracting, recovering and retaining talent**<sup>106</sup>, so that our brightest researchers and engineers can take part in this project of knowledge transfer and transition to a new society and economy.

## RECOMMENDATION 5: AI FOR THE USE OF PUBLIC ADMINISTRATIONS DATA

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This Strategy should serve to promote the establishment of a basis for the enormous amount of **open and public data** generated, and not limited to RDI, to be modeled, analyzed, used and exploited in a safe and ethical way by the administration that generates them or by other administrations, in order to obtain the maximum benefit from open data using AI techniques, improving the efficiency and efficiency of their processes, creating platforms for public-private collaboration and reducing costs. Likewise, the channels should be identified so that private companies that use open data can share part of their data with the public administration with the aim of offering better public services, guaranteeing social welfare and individual and public security. In order to minimize the risks involved in using open public sector data without certification processes, it is recommended that a **National Data Institute** be set up to plan and define governance over data from national, regional and local Public Administrations.

This initiative would allow: formulating a National Data Plan with regular updates; define a governance, organizational structure and inter-ministerial procedures; define a set of regulations, standards and procedures aligned with EU directives; analyze the reuse and exploitation of open data from the public sector; exploit open and closed data using IA techniques; provide a point of contact to advise the different Public Administration bodies on AI strategies to be carried out to learn how to extract new knowledge from the data using AI techniques; to offer specific training in AI to public employees in order to make the most of the data they have, and thus contribute to the improvement of Public Policies; to establish channels by which private companies can or must share part of their data with the Public Administration with the aim of offering better public services and creating public-private collaborations in which data are shared that allow innovative value-added services to be offered, always respecting privacy and data protection regulations, for the benefit of citizens and the functioning of public administrations.

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<sup>106</sup> The Council of Ministers has approved through Royal Decree-Law 11/2018 of 31 August, the transposition of Directive (EU) 2016/801 of the European Parliament and of the Council of 11 May 2016 on the entry and residence requirements for third-country nationals for the purposes of research, studies, traineeships, voluntary work, pupil exchange programs or educational projects and au pair placement, This implies real and tangible support for the internationalization and attraction of talent from universities, R&D&I bodies and research centres, simplifying administrative procedures, reducing the time taken to obtain residence permits, and collecting the demand for facilities that favour arrival and stay, such as the possibility of teaching, travelling with their relatives or residing and researching in more than one European country. The main novelties introduced by this Royal Decree-law are a package of measures to speed up, simplify and make more flexible the administrative procedures for the arrival of foreign students and researchers, who will enjoy a "fast track", and the development of the authorization of residence for research, for nationals of third countries who wish to carry out training activities, research, development and innovation in public or private European entities, and who have a visa or authorization of residence for training or research.

## RECOMMENDATION 6: INCLUDE AI IN THE EDUCATION SYSTEM AS A LEVER FOR TECHNOLOGICAL CHANGE IN THE COUNTRY.

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Education in computational thinking in Spain can be improved when we analyze its backwardness with respect to the European environment<sup>107</sup>. R+D+I can contribute to the need for intervention aimed at improving our scientific-technological culture, together with other social and emotional competences that are capable of boosting and enriching computational capacities. In order to adequately train citizens and their governors in general as well as future IA experts, it is necessary to change our **educational model**, training them to think and act and not just to know. It seems necessary to update education plans so that they are in line with the technological present (and future) in which we live, from Primary and Secondary Education, through University training or Vocational Training (contemplating the formative hybridization of science, technologies and humanities), to reaching their specialization in the labor market and maintaining a thanks to update lifelong learning programs.

In order to ensure mastery of these skills, it is essential to promote training from the earliest levels of education. This necessarily requires the training of trainers. On the other hand, informatics in general, and IA in particular, are very dynamic disciplines, which necessarily implies that their curricula should be more flexible in order to be able to adapt to scientific, technological, economic and social contexts. As for postgraduate levels, and specifically in the case of doctoral programs, it would be advisable to promote them, within the framework of an appropriate certificate, through instruments such as Vocational Education scholarships with AI profiles, as well as through the promotion of industrial theses that allow for the transference between Universities, research centres and public and private companies.

## RECOMMENDATION 7: ENSURE THE ETHICAL USE OF AI IN ALL ITS FIELDS OF APPLICATION

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Over the past ten years, the achievements of IA have generated serious questions about the direction and implications of these technologies for society and the economy. Not only should scientific and technological advances impact the development of IA technologies. Watching over the economy and society presents itself as a challenge, so the development of new applications must be guided by the **ethical, legal and social principles** of Spain and Europe that will be included in an Artificial Intelligence Code of Ethics co-developed at the **inter-ministerial** level.

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<sup>107</sup> [https://intef.es/wp-content/uploads/2017/02/2017\\_0206\\_CompuThink\\_JRC\\_UE-INTEF.pdf](https://intef.es/wp-content/uploads/2017/02/2017_0206_CompuThink_JRC_UE-INTEF.pdf)

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<sup>1</sup> [https://intef.es/wp-content/uploads/2017/02/2017\\_0206\\_CompuThink\\_JRC\\_UE-INTEF.pdf](https://intef.es/wp-content/uploads/2017/02/2017_0206_CompuThink_JRC_UE-INTEF.pdf)

## ACRONYMS

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**PA** Public Administrations

**AEI** State Research Agency

**AEPAI** Asociación Española para la Inteligencia Artificial (Spanish AI Association)

**AGE** General State Administration

**ALHLEG** High-Level Expert Group on Artificial Intelligence

**APL** Application Programming interface

**BIM** Building Information Model

**BSC-CNS** Barcelona Supercomputing Center

**CCAA** Autonomous Regions

**CDTI** Centro para el Desarrollo Tecnológico Industrial (Technological Industrial Development Centre)

**CEEI** Comité Español de Ética de la Investigación (Spanish Ethics in Research Committee)

**COM** Comisión Europea (European Commission)

**CSIC** Agencia Estatal Consejo Superior de Investigaciones

Científicas (State Agency Higher Council for Scientific Research)

**CVC-UAB** Centro de Visión por Computador, Universidad

Autónoma de Barcelona (Computer Vision Center, Universidad

**DIH** Digital Innovation Hubs

**EBT** Empresas de base tecnológica (Technology-based companies)

**ECTI** Estrategia Española de Ciencia, Tecnología e Innovación (Spanish Strategy in Science, Technology and Innovation)

**EOSC** European Open Science Cloud

**GTAI** Grupo de Trabajo en Inteligencia Artificial (AI Work Group)

**IIAI-CSIC** Instituto de Investigación en Inteligencia Artificial del

Consejo Superior de Investigaciones Científicas (AI Research Institute of the State Agency Higher Council for Scientific Research)

**RDI** Research, Development and Innovation

**ISCIII** Instituto de Salud Carlos III

**KETS** Key Enabling Technologies

**MCIU** Ministry of Science, Innovation and Universities

**MFP** EU Multiannual Financial Framework

**MINCOTUR** Ministry of Industry, Trade and Tourism

**MINECO** Ministry of Economy and Enterprise

**OECD** Organisation for Economic Co-operation and Development

**ODS** Objetivos de Desarrollo Sostenible (Sustainable Development Objectives)

**PECTI** Planes Estatales de Ciencia, Tecnología e Innovación (Science, Technology and Innovation State Plans)

**PRACE** Partnership for Advanced Computing in Europe

**RD** Royal Decree

**RES** Red Española de Supercomputación (Spanish Super-computing Network)

**RISP** Reuse of Public Sector Information

**RES** Red Española de Supercomputación

**RISP** Reutilización de la Información del Sector Público (Spanish Super-computing Network)

**SEAD** State Secretariat for Digital Advancement of the Ministry

of Economy and Enterprise

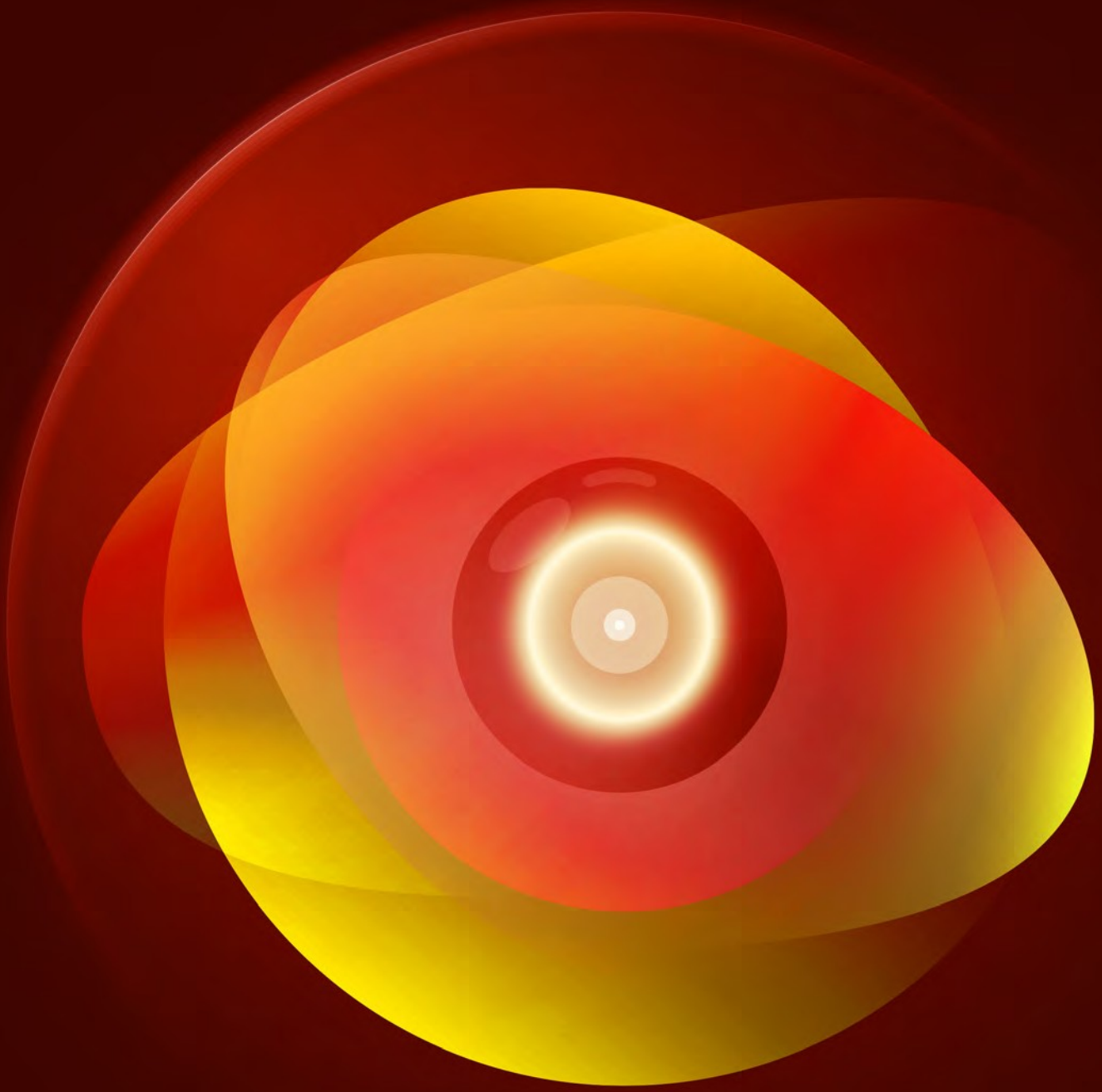
**SECTI** Spanish Science, Technology and Innovation System

**SGCPC** General Secretariat for Science Policy Coordination

**UE** Unión Europea (European Union)

**UGR** Universidad de Granada

**UPC** Universidad Politécnica de Cataluña



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