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# 1. INTRODUCTION

Task 4.4, led by the University of Twente, aims to encourage and facilitate the early adoption of AI-Data-Robotics (ADR) technologies across European Member States by enhancing knowledge about regional and national innovation strategies. During workshops, the underlying factors contributing to the efficacy of regional or national innovation models were explored, and the lessons that other regions and Member States can derive from them were subject to discussion. For this study, a limited number of successful inspiring cases were selected as illustrative examples based on insights gathered through workshops, interviews, and discussions. Two regional robotics cases (Twente and Odense) and three national AI cases (the Netherlands, Finland, and Croatia) were chosen for a more comprehensive analysis of the development of their ADR ecosystems.

Task 4.4 has supported Adra in establishing the Topic Group titled “Innovation, Deployment, and Uptake of ADR Technologies.” The Task 4.4 lead has been appointed as the coordinator of this group and several individuals who have actively contributed to workshop discussions have become members of this Topic Group. Consequently, the activities and accumulated knowledge related to this Adra-e task are seamlessly integrated into this Adra Topic Group.

- Chapter 3 ‘Extended Summary’ provides an overview of the project’s activities and outcomes.
- Chapter 4 presents take-aways from the workshops and offers an overview of international and European key trends and developments in national AI strategies.
- Chapters 5 and 6 delve into the regional robotics ecosystems of Twente (Netherlands) and Odense (Denmark).
- Chapters 7, 8, and 9 describe the national AI strategies of Croatia, the Netherlands, and Finland.
- Chapter 10 concludes the report with a summary of activities and findings

# 2. DOCUMENT SUMMARY

Deliverable D4.8 outlines the approach and outcomes of Task 4.4, led by the University of Twente. The primary objective was to enhance insights regarding regional and national innovation strategies for AI-Data-Robotics (ADR) technologies. This understanding was intended to encourage, promote, and facilitate their adoption across European Member States.

To facilitate dialogues between innovative approaches and initiatives, various workshops were organized, thereby enhancing the collaborative knowledge of beneficial instruments for the adoption of ADR technology. These workshops showcased successful regional and national approaches and discussed the added value of different European instruments. This facilitated a deeper understanding of the underlying factors contributing to the efficacy of regional or national innovation models and the lessons that other regions and Member States can derive from them.

Based on a series of interviews and the findings of the workshops, five cases were selected for a more in-depth analysis of their innovation ecosystems: two regional robotics cases (Twente and Odense) and three national AI cases (the Netherlands, Finland, and Croatia). The two 'old industrialized regions', Odense and Twente, share a remarkable parallel industrial history. Both regions experienced significant job losses, which prompted regional governments to take action. They achieved the necessary significant economic restructuring, but did so in different ways. Also, the development of the national AI strategies of Finland, the Netherlands, and Croatia demonstrates interesting similarities and differences. Finland and the Netherlands were among the frontrunners in establishing their AI strategy, while Croatia has recently announced the commencement of the process.

Task 4.4 also supported Adra in establishing the Topic Group titled "Innovation, Deployment, and Uptake of ADR Technologies" to ensure that the activities and accumulated knowledge were seamlessly integrated into this Adra Topic Group.

# 3. EXTENDED SUMMARY

This report describes the approach and results of Task 4.4, led by the University of Twente. The goal of the activities was to encourage and facilitate the early adoption of AI-Data-Robotics (ADR) technologies across European Member States.

Various workshops were organized to facilitate dialogues between innovative approaches and initiatives and to enhance shared understanding regarding regional and national innovation strategies, as well as effective national and European instruments stimulating the adoption of ADR technology. This facilitated a deeper understanding of the underlying factors contributing to the efficacy of regional or national innovation models and the lessons that other regions and Member States can derive from them.

For this study, a limited number of successful cases were selected as illustrative innovation examples based on insights gathered through the workshops, interviews, and discussions. Two regional robotics cases (Twente and Odense) and three national AI cases (the Netherlands, Finland, and Croatia) were chosen for a more comprehensive analysis of the development of their ADR ecosystems. They all have interesting similarities and differences in approaches.

At the ADRA23 event, ADRA signed a MoU with EIT Digital, a prominent international innovation network with extensive experience in technology adoption and startup support. Task 4.4 actively facilitated this collaboration, including regular joint taskforce meetings.

Task 4.4 also supported Adra in establishing the Topic Group titled “Innovation, Deployment, and Uptake of ADR Technologies.” The Task 4.4 lead has been appointed as the coordinator of this group, and several individuals who have actively contributed to workshop discussions have become members of this Topic Group. Consequently, the activities and accumulated knowledge related to this Adra-e task are seamlessly integrated into this Adra Topic Group.

## 3.1 WORKSHOPS

A literature study and multiple interviews and discussions with stakeholders from exemplary ADR ecosystems were conducted. Workshops were (co)organized during various events of Adra (including its ADRf forum event in 2023 and 2024 and Adra’s Future Ready event in 2025), the annual event of the Adra founding organization euRobotics, (the European Robotics Forum ERF in 2025), and several events organized by Adra-e. Additionally, Task 4.4 actively participated in a couple of other events organized by the ADR community.

The workshops commenced with concise and inspiring presentations of diverse regional and national “best practices” that could serve as inspiring learning opportunities. Additionally, presentations were delivered on the available European innovation instruments, highlighting their potential impact and role within regional and national innovation systems. The examples selected for these presentations were primarily derived from the earlier conducted interviews and literature reviews. These inspiring presentations served as input and catalyzed the discussion during the workshops on the best practices for AI and robotics adaptation.

Simultaneously, the added value and limitations of the national and European instruments designed to promote the uptake and adoption of ADR became more evident. The majority of workshops had a participant count between 20 and 50, comprising a highly diverse group of researchers, entrepreneurs, representatives from regional and national governments, and intermediary organizations. When a workshop had many participants, the group was divided into two for the interactive discussion part. The primary findings were subsequently shared in the plenary session.

European mapping activities conducted by Adra-e Task 2.1 and other European projects provide valuable data, including key players, their locations, quality, and output. These activities complement the insights gained from Task 4.4, which is primarily focuses on identifying the factors contributing to the effectiveness of regional or national innovation models and the lessons they can learn from each other. The fundamental data information is important for Task 4.4, which primarily focused on identifying the types and effectiveness of regional, national, or European innovation instruments and initiatives that contributed to the success of ADR ecosystems and the role of governments at both regional and national levels. Consequently, several workshops were organized in close cooperation with the more ecosystem-mapping-oriented activities within the ADR community.

As an example, the workshops highlighted the importance of European instruments, such as the European Digital Innovation Hubs (EDIHs) that serve as regional hubs to assist SMEs in their digital transformation and enhance their digital maturity. These hubs offer a range of services to help local SMEs overcome challenges in, for example, digitalization, robotics, cybersecurity, and AI. EDIHs also provide access to investment support. Additionally, EDIHs address the specific needs of SMEs in navigating the complex regional and European landscapes of expertise, knowledge, and resources. The Test-Before-Invest facilities of EDIHs primarily focus on more mature ADR technologies that are ready for deployment. The European Test and Experimentation Facilities for AI (TEF) model also presents promising opportunities. TEFs, though fewer in number compared to EDIHs, support technology providers in developing new solutions and validating them in real-world environments, bringing them closer to the market. TEFs concentrate on more innovative issues. Because technologies tested in TEFs may not have reached the same level of maturity as those tested in EDIHs, they still require substantial testing and validation before deployment. TEFs concentrate on more innovative issues.

For both European instruments, national choices and co-funding are crucial. Some countries are clearly more capable of achieving this than others. Some EDIHs primarily operate within a region, while others have a much broader national role. The strong connection between the TEF and EDIH in Odense (Denmark), highlighted during one of the workshops, particularly captivated the audience’s attention as a very efficient way of working. This comprehensive one-stop-shop approach really serves as a valuable resource for SMEs, especially if it includes the new European tool ‘AI factories’ as well. EDIHs, TEFs, and AI Factories are powerful European instruments that effectively stimulate innovation within European regions, and they complement each other well.

Additionally, the workshops showcased the distinct approaches and added value of the EDIH (European Digital Innovation Hubs) concept in comparison to the earlier pan-European networks of Digital Innovation Hubs (DIHs) established during the Horizon 2020 program. The DIH networks primarily focus on innovators and early adopters of SMEs. Their expertise spans the entire application-domain-specific innovation chains across Europe. They possess in-depth knowledge of the relevant legislation, market, standardization, key players, industrial structure,

and other pertinent factors pertaining to these specific application domains. In contrast, the new EDIHs are more generic, place a stronger emphasis on regional businesses, and allocate relatively less attention to specific application domains with their unique requirements and international innovation chains. During the workshops, it became evident once more that, in addition to the more general approach of EDIHs, SMEs truly need in-depth application-domain-specific support and tools that empower them to actively participate in Europe-wide innovation networks.

Strategic partnerships enable Adra to provide certain services to its members more swiftly and effectively compared to developing them on their own. One such partnership is with EIT Digital, which has amassed extensive knowledge and a vast international network over the past 15 years in the fields of innovation, technology adoption, and start-up and scale-up support. Following the signing of the Memorandum of Understanding (MoU) between Adra and EIT Digital during the ADRf23, Task 4.4 actively supported this collaboration, including regular joint taskforce meetings between Adra and EIT Digital.

Several interviews and workshops have revealed that access to financing is often a significant barrier to further business growth, particularly for young and small companies. SMEs encounter not only the difficulty of securing funding, but also the challenge of establishing connections with the right investors who provide not only financial support, but also valuable guidance, expertise, and networks. Therefore, organizing access to capital is a crucial building block for innovative regions, countries, and their ecosystems. This is why the dynamics during the Investors' Brunch were so intriguing, which was organized by EIT Digital together with Adra and Adra-e and the Dutch AiNed and Topsector ICT. During 10-minute round table pitch sessions, 18 promising start-ups and scale-ups had the chance to introduce their vision, products, and growth strategy, to engage with 12 experienced investors from across Europe specialized in the ADR domain. The sessions were designed to facilitate focused introductions and rapid networking.

The workshop, which brought together the long-established Dutch AI ecosystem with Croatia's young and developing AI ecosystem, fostered an engaging discussion on how to cultivate a thriving AI innovation ecosystem. Key points of discussion included establishing a community-building pillar, using the opportunities of bringing together individuals from diverse backgrounds, including representatives from the creative sector, and setting up a European AI Forum to facilitate dialogue between policymakers lacking technical expertise and the tech community lacking understanding of laws and policies.

During another workshop, one of the presenters explored the differences in national AI strategies between the Netherlands, Finland, and Sweden. For instance, the Netherlands used existing innovation instruments, a departure from the approach taken by several other countries. Finland adopted a more rapid top-down approach centered around scientific excellence, while the Netherlands opted for a consensus-building approach involving numerous stakeholders. Also several other differences and similarities were discussed, each with its advantages and disadvantages.

It was gratifying to witness that representatives from the German Ministry of Economic Affairs followed up with several presenters after a workshop where discussions centered around the establishment of the new R&D funding agency in the UK, the establishment of the new Robotics Institute in Germany, and the combined regional/national robotics approach of Denmark.

Therefore, these workshops not only deepened the understanding of how regional, national, and European instruments can effectively support ADR innovation, but also fostered stronger connections among diverse stakeholders across Europe.

## 3.2 REGIONAL ROBOTICS CLUSTERS: ODENSE AND TWENTE

Two robotics cases were chosen for a more comprehensive analysis of the development of their robotics ecosystems. regional Odense in Denmark and Twente in the Netherlands share a remarkable parallel industrial history. Both regions are ‘old industrialized regions’, characterized by an early industrial revolution that laid the basis for their heavy industry sectors such as textiles in Twente and shipbuilding in Odense, followed by a spiral of decline since the second half of the 20th century, ultimately leading to major company closures and job losses. In the Twente region, the textile industry relocated to Asia, while in Odense, the shipyards faced intense competition from Asian manufacturers and ultimately had to close down. Consequently, they both experienced significant job losses, prompting regional governments to act. They achieved the necessary significant economic restructuring, but did so in different ways.

Since the early 1980s, ship manufacturing shifted more and more to Asia, and in 2009, the Odense Steel Shipyard announced its closure. In collaboration with industry, the university in Odense had already established a notable robotics research center. This laid the foundation for further development of a strong regional robotics cluster. Thus, the closure of the shipyard didn’t lead to a spiral of decline but to the revitalization of the region. Numerous companies started, thrived, and grew from this fertile ground. Furthermore, the acquisition of Universal Robots put Odense on the world map, making it internationally recognized as a leading robotics ecosystem. Simultaneously, the robotics industry in other Danish regions was growing, and several national initiatives were implemented, including a national robotics program and a national program to shape industrial clusters. Odense Robotics became Denmark’s national robotics, automation, and drone cluster, headquartered in Odense with regional robotic hubs across the country. This national cluster played a crucial role in establishing Denmark as an international hub for robotics. The local university played an important role in the transformation throughout the entire process.

The cluster's development involved many contributors, but it ultimately depended on the right entrepreneurs. Public actors at both local and national levels also played key roles, fostering innovation and taking risks when private investors held back. The Danish robotics cluster stands as a remarkable example of a successful industrial cluster that emerged during a period of deindustrialization. It became a story of a great industrial rebirth, a remarkable industrial renaissance.

By the late 1970s, most clothing factories in Twente were closed, and the textiles’ economic decline had reached a crisis point. Old industrial areas were growth poles during the Industrial Revolution, but creating structural change in such regions poses challenges. A university can play a crucial role in breaking free from the past, but Twente was lacking a university. After a successful lobby by local government and companies to influence the national government, the region was granted permission to establish a new university to provide the region with a new impetus. The university has successfully embraced this role. It has been instrumental in building local networks and fostering connections with global developments. The university has acted as a growth node, generating new activities, particularly new businesses. These networks have

developed their own growth dynamics and eventually become mutually reinforcing. Although mechanical engineering and electrical engineering were core fields from the university's inception, the regional economic restructuring was not initially focused on robotics. In the beginning, the renewal was centered around developing a generic high-tech innovation ecosystem. Later, domain-specific instruments were added to support the robotics sector. With its robust high-tech industry, numerous successful start-up companies, and thriving robotics community, Twente truly emerges as a breeding ground for next-generation robotics. The Twente region example serves as a compelling example of how a university can contribute to the renewal of old industrial areas.

Both Odense and Twente successfully transformed from declining industrial regions into vibrant robotics hubs, with universities playing a central role in driving innovation and entrepreneurship. In Odense, the transformation was rooted in an existing industrial base and accelerated by early investments in robotics research, supported by coordinated national initiatives. In contrast, Twente's renewal began with the creation of a new university to spark regional revitalization, initially focusing on a broader high-tech ecosystem before evolving into a robotics cluster. While Odense benefited from a top-down national cluster strategy, Twente's approach was more bottom-up and gradual, illustrating two distinct yet effective paths to industrial renewal.

## 3.3 NATIONAL AI STRATEGIES: CROATIA, THE NETERLANDS, FINLAND

As we approach profound transformations, the AI policy landscape has emerged as a significant determinant of competitiveness. Its influence will significantly shape our future. AI has become an indispensable social and economic policy priority, prompting governments to intensify their AI initiatives through strategy plans, regulatory frameworks, and substantial investments. Almost all European Member States have developed national AI strategies. While these strategies differ in their focus, levels of maturity, implementation speed, investment allocations, and technological capacity, they generally converge on the objective of augmenting research endeavors, enhancing data infrastructure, and addressing governance and ethical concerns.

National AI strategies typically outline key objectives and provide action plans to implement the strategy. Although there's no universal model for a national AI strategy, countries can benefit from shared practices. By learning from and being inspired by each other's approaches, nations can develop and maintain effective national AI strategies. Regardless of the national context, developing and maintaining a national AI strategy requires continuous adjustments and updates.

Three national AI cases were chosen for a more comprehensive analysis of the development of their national AI strategies. The AI strategies of the Netherlands, Croatia and Finland show both interesting similarities and differences. With their national AI strategies published in 2017, the United Kingdom and Finland were among the pioneers in Europe. Denmark, France, Germany, and the Netherlands followed in 2018 and 2019. Several other European countries joined the race in 2020, including Bulgaria, Hungary, Poland, and Spain. Croatia, however, was among the later countries to develop and adopt a national AI strategy.

Already in 2018, the Croatian government established a working group to draft the document. But it missed its original 2019 deadline, and mid-2022 Croatia was even one of the few EU member states that had not yet established an official national AI policy. In December 2022, the Croatian government published the "Digital Croatia Strategy for the Period Until 2023". While

the report addressed AI, it is not regarded as a comprehensive national AI strategy. Croatia still lacks a formal national AI strategy, but in May 2025, the country announced its intention to initiate a national AI Development Plan together with an AI Action Plan for the period 2026-2032.

Finland and the Netherlands consistently rank among the top European countries regarding AI capabilities and readiness. However, when considering global rankings, they occupy a middle position.

- In the Government AI Readiness Index, out of the 188 countries compared, the Netherlands ranks 7th, Finland 9th, and Croatia 74th (*Oxford Insight, 2024*).
- In Stanford's AI Vibrancy Index of 36 countries, the Netherlands ranks 15th, and Finland 20th. Croatia was not included in the index (*Masjlej, 2025; Stanford University, n.d.*).
- In the Tortoise Global AI Index comparing 83 countries, the overall rank of the Netherlands is 13th, Finland 15th, and Croatia 44th (*Tortoise, n.d.*).

### 3.3.1 Development of national AI Strategy Plans in Finland, the Netherlands and Croatia

In all three countries, the government played a pivotal role in shaping the national ecosystems.

- ***Finland*** launched its first national AI strategy in 2017, with the primary objective of developing and positioning itself as a global leader in the field of AI. The strategy emphasized scientific excellence, innovation, and leadership in the AI domain. Finland promptly allocated the necessary resources to achieve this goal. The strategy underwent further refinement and revision in 2018. Following the 2019 election, the newly formed coalition government adopted a different perspective on AI, and in 2020, the Finnish AI strategy underwent an update. In this new AI strategy plan, two developments were combined: AI and Industry 4.0. In 2022, the updated AI strategy plan, titled "Artificial Intelligence 4.0 programme - Finland as a leader in twin transition," was published, in which a vision for Finland 2030 was articulated. The report underscores the double green and digital transitions and articulated the ambitious goals to make Finland a pioneer and an international leader in both AI and the twin transition. In this report, a diverse array of cutting-edge digital technologies was presented, including AI, robotics, quantum computing, high-performance computing, and the Internet of Things, as essential components in achieving these objectives.

  Responding to the fast advancements in AI worldwide necessitates knowledge sharing and capacity and competence building among research and innovation communities. This is why the Nordic countries have been collaborating intensively for many years. This cooperation is further developing with the recently initiated ambitious cooperation to establish a cross-border joint AI research and innovation center. This project will expand collaboration in key technology areas, including AI, cybersecurity, and digitization. It is funded by all five Nordic states, including Iceland. By working together, the Nordic countries can swiftly, flexibly, and effectively address their shared priorities and needs.

- In ***the Netherlands***, the process of shaping and implementing the national AI plan spanned several years, encompassing coalition building and agreeing on the strategy. The government engaged a diverse and large group of stakeholders, which enhanced public

support and social acceptance but also led to delays in the process. Achieving a balance between the priorities and interests of all stakeholders across various sectors and regions posed a significant challenge. This Dutch consensus-model is less agile compared to more top-down models employed in several other countries. When the national AI strategy was finalized in 2019, the government opted to utilize existing funding instruments, resulting in a rather complicated route to allocate funds for the implementation of the strategy. This approach necessitated a collaborative proposal from many different stakeholders. A significant challenge was to assemble that diverse group of stakeholders, encompassing academia, industry, civil society and government, each with its own interests and working styles. Another challenge was to preserve focus and coherence within the proposal, ensuring its alignment with the overarching national AI strategy and its objectives. This approach was not particularly conducive to a swift process. This slowdown is also evident in the realm of computer computing power, where the Netherlands significantly trails behind Finland. The development of new AI models and applications necessitates specialized computers, and those with substantial computing power are at the forefront of advancements. Finland boasts a powerful EuroHPC LUMI AI Factory, while stakeholders in the Netherlands are still in the deliberation phase

The 'Strategic Action Plan for Artificial Intelligence' (SAPAI) in 2019 marked the commencement of the first Dutch AI Research and Innovation policy. The resulting Public-Private-Partnership 'Dutch AI Coalition' (NLAIC) and the strategic AI investment program AiNed, which are recently combined into the 'AI Coalition 4 Netherlands' (AIC4NL), constitute the fundamental pillars of the Dutch approach. The AIC4NL's objective is to organize the Dutch AI ecosystem, accelerate AI development, and consolidate AI initiatives from participating organizations to mitigate fragmentation and inefficiency. Beyond mobilizing a robust network of partners from crucial economic and societal sectors, the AIC4NL plays an integral role in both program development and implementation. This combination of ecosystem mobilization power and program execution capabilities is regarded as very important for widespread rapid adoption of AI innovations. The AIC4NL guides the entire AI development cycle, encompassing fundamental research to testing applications in pilots and scaling up validated concepts, while ensuring that each step adheres to ethical and societal standards. Its close ties with governments at regional, national, and European levels facilitate the organization's effective switch between policy and practice. Furthermore, through its regional AI hubs, the AIC4NL is deeply embedded in the regions, providing support in addressing local challenges.

- ***Croatia's*** approach to AI policy diverged from many European countries that began developing formal strategies around 2018-2019. Initially, Croatia's AI policy was shaped by industry-led initiatives rather than government-directed programs. While a government initiative to develop a national AI Strategy Plan commenced in 2018, it faced significant delays. It wasn't until December 2022 that a national digital strategy, encompassing AI, was published. However, this strategy was not a comprehensive national AI Strategy Plan. Nowadays, Croatia still does not have a formal national AI strategy. A pivotal moment came in 2019 with the establishment of CroAI, which organized the country's AI ecosystem and created a platform for collaboration across sectors and disciplines. Croatia's AI innovation model is not built around infrastructure or investment volumes, but rather around people. Notably, CroAI's community-building strategy encompassed specific activities aimed at engaging the creative sector within the AI innovation ecosystem. Over the past few years, Croatia has established a dynamic and growing AI ecosystem that demonstrates significant potential despite the country's relatively small size.

Despite the absence of a national AI strategy, Croatia has taken steps to develop one. In May 2025, Croatia announced its intention to initiate the development of a National AI Development Plan for the period up to 2032, along with a corresponding Action Plan for 2026-2028. The development process will involve government bodies, the civil and private sectors, and the academic community. The plan focuses on areas such as education and skill development, digitalization of the private sector, financial incentives, and protecting citizens' rights and privacy. Croatia's journey in AI development illustrates that even smaller countries can make significant contributions to the global AI landscape when they mobilize diverse stakeholders, foster a culture of dialogue and innovation, and connect with international networks.

### 3.3.2 Ethical, Legal, Social and Economic aspects (ELSE)

Europe must significantly increase its investments in AI while upholding its fundamental principles of trust, ethics, and human-centric governance. In 2024, the European Parliament enacted the landmark EU AI Act and established its AI Office, thereby creating a framework that ensures that AI upholds human rights, democracy, and the rule of law. This demonstrates Europe's growing commitment to cooperation in addressing AI risks and fostering global trust in its development. Member States are also streamlining their own AI strategies and governance frameworks.

Continued international collaboration and the implementation of initiatives like the EU AI Act are essential to ensuring Europe keeps pace and contributes to shaping a responsible global AI future. Globally, high-income countries tend to emphasize regulation and ethical guardrails, while emerging economies are rapidly entering the AI field, often prioritizing foundational capacity-building. Simultaneously, global investment in AI is experiencing significant growth, and divergent approaches, such as the West's cautious ethics-driven models and the East's aggressive R&D focus, shape competitive dynamics.

Research and technology advancements can lead to significant scientific and technological impacts, which can have economic impacts when they align with business challenges. However, the success and economic and societal impact of AI technologies also depend on their widespread societal acceptance. Consequently, many national AI strategies address policy concerns related to privacy, safety and accountability, societal acceptance, algorithmic bias, transparency and explainability, and more. The development of AI technology and its social embedding must be intertwined.

- ***Finland's strategy*** using AI for economic growth and societal advancement balances technological innovation with ethical considerations. In 2024, the Nordic countries embarked on an ambitious project to establish a cross-border joint AI research and innovation center. This center aims to foster responsible and ethical AI use, enhancing security and bolstering business competitiveness. Regional research and innovation cooperation, coupled with the sharing of best practices, is crucial to addressing both the opportunities and the technical and ethical challenges posed by AI. A unified Nordic AI strategy, integrating expertise, resources, and innovative capabilities, enables the efficient development of robust and ethically sound AI systems and services.

- EU legislation and policies, such as the AI Act and the Digital Europe program, significantly influence the ***Dutch' strategy***. The Netherlands recognizes the significance of these preconditions and places a strong emphasis on ethical, legal, social acceptance, and economic (ELSE) aspects in its AI strategy. The ELSA Labs serve as a platform to give ELSE issues a prominent place, where ELSE aspects and technology development are studied in tandem. This approach is particularly relevant to application domains that hold strategic social and economic importance and are key to the major transitions we are facing.

- The European AI Forum, established by ***Croatia***, facilitates dialogues between policymakers, often lacking technical expertise, and the tech community, often lacking understanding of laws and policies. An instrument like the 'Fight Club' encourages discussions on challenging topics, such as determining liability when AI makes incorrect decisions. Regulatory Sandboxes offer a safe testing environment for developing and implementing AI, while ensuring appropriate safeguards. These sandboxes allow testing of AI products in real-world settings with relaxed regulatory requirements and the necessary safeguards in place.

### 3.3.3 European cooperation

International collaborations are important for responsible and effective adoption of AI. Shared frameworks, international standards, and regional cooperation empower governments with access to resources, best practices, and a shared understanding of the potential and risks associated with AI. The European Union's approach to AI is underpinned by a commitment to excellence and trust. Its objective is to foster research and industrial capacity while simultaneously ensuring the safety and protection of fundamental rights. The European AI ecosystem is characterized by its complex, interconnected, and highly collaborative nature. Europe's performance in international benchmarks, like the Government AI Readiness Index, underscores its strong governance structures, advanced data infrastructure, and commitment to innovation. However, sustained investment in AI research, digital infrastructure, skills development, and enhanced coordination across governments, stakeholders, and international partners is crucial for maintaining competitiveness in the rapidly evolving global AI landscape.

AI is a key priority for both Horizon Europe and Digital Europe, Europe's primary funding programs for research, development an innovation. Researchers from European Member States actively participate in numerous research and innovation projects.

Especially for SMEs, European tools such as EDIHs (European Digital Innovation Hubs), TEFs (AI Test and Experimentation Facilities), and AI Factories are important instruments to foster AI development and AI adoption in society. National choices and co-funding are needed for these European initiatives. Some countries are clearly more capable of achieving this than others.

- EDIHs serve as local one-stop shops, providing support to SMEs' digitalization. They offer Test-before-Invest facilities, access to funding, networking, and training services. The European-wide EDIH network enables SMEs to seek support from other EDIHs when local knowledge and expertise are lacking. The new EDIHs 2.0 must even focus much more on supporting SMEs to adopt AI and have to be able to refer them to relevant AI-actors such as AI Factories and TEFs. Finland, the Netherlands and Croatia have regional EDIHs.

- To expedite the market entry of trustworthy AI and enhance its uptake, the European Commission has established sectorial 'AI Testing and Experimentation Facilities' (TEF) for

AI. Access to these sandboxes and quasi-real-world AI test and experimentation facilities empowers SMEs and AI technology developers to identify potential technical flaws and governance challenges, facilitating the faster market entry of their new AO tools. Finland and the Netherlands are involved in several of these TEF networks.

- The development of new AI models and applications necessitates specialized computers, and those with sufficient computing power are at the forefront of these developments. The recently established general-purpose 'AI Factories' of the European 'High Performance Computing Joint Undertaking' EuroHPC foster AI development by facilitating access for SMEs and AI startups. These AI Factories are networked together and connected to other European AI initiatives such as TEFs and EDIHs. There are currently 13 AI Factories approved by the EC; one of them is LUMI AIF in Finland.

European partnerships, which involve collaboration between the European Commission, public, and private sectors, serve as important implementation platforms for Horizon Europe. EU Member States actively participate in these Public-Private-Partnership networks and various intergovernmental organizations, including the AI-Data-Robotics Association Adra, the EuroHPC Joint Undertaking, the Big Data Value Association (BVDA), euRobotics, the Confederation of Laboratories for AI Research in Europe (CAIRNE), and the European Laboratory for Learning and Intelligent Systems (ELLIS).

Finland, the Netherlands, and Croatia actively participate in Adra. Several members of Adra's Board of Directors are from Finland and the Netherlands. For many years, Finland has been hosting the local ELLIS node in Helsinki. In 2024, this node has been expanded into the second ELLIS institute, marking a significant expansion of the ELLIS network in Northern Europe. The Netherlands host three ELLIS Nodes: one in Amsterdam, one in Delft and one in Nijmegen. CAIRNE has its headquarters in the Netherlands; researchers from Finland also participate in the CAIRNE network. Finland and the Netherlands are also strongly involved in European networks like BDVA and euRobotics, often having representatives on their Board of Directors.

These national AI strategies show that AI has become a strategic priority across Europe, with countries pursuing diverse approaches tailored to their national contexts. Finland and the Netherlands illustrate how coordinated policy, investment, and ecosystem engagement can drive progress, while Croatia's evolving efforts show the potential of bottom-up, community-led initiatives.

As the EU AI Act takes effect, continued collaboration, knowledge sharing, and investment will be essential to ensure Europe remains competitive and leads in developing ethical, human-centric AI.

# 4. STIMULATING THE UNDERSTANDING OF INNOVATION WITH, AND ADOPTION OF ADR TECHNOLOGIES

## 4.1 AIM OF TASK 4.4

WP4 'Boosting the adoption of AI technology', led by the UvA, aims to encourage and support AI-Data-Robotics (ADR) technology adoption across the value chain, from research to procurement. Task 4.4, led by the University of Twente, aims to encourage and facilitate the early adoption across European Member States by deepening the knowledge about regional and national strategies. By presenting a selection of inspiring exemplary effective innovation ecosystems approaches ('best practices'), Task 4.4 stimulated the understanding of how various European regions and/or countries' innovation with, and adoption of ADR technologies is organized and empowered. These best practices vary by region, country, application domain, and technology, showing a wide range of approaches. At the same time, regional and national initiatives possess valuable insights into what makes these approaches effective.

A literature study and multiple interviews and discussions with stakeholders from exemplary effective ADR ecosystems were conducted. To foster the dialogue between approaches and initiatives and to increase the joint knowledge about useful instruments for ADR technology adoption, several workshops were organized during events of Adra, euRobotics, and Adra-e.

Numerous ecosystems serve as inspiring examples of ADR innovation and adoption. As mentioned before, the innovation practices differ by country, region and technology. For this study a limited number of particularly successful cases were selected as illustrative examples based on insights gathered through the workshops, interviews and discussions. Two regional (Twente and Odense) and three national (the Netherlands, Finland and Croatia) cases were selected for a more in-depth analysis of the development of their ADR ecosystems.

## 4.2 INTERVIEWS AND DISCUSSIONS

The main objective of the interviews and discussions was to identify regional and national best practices within the diverse technology domains of AI, Data, and Robotics. Among the key individuals who participated in these activities were:

- **Morten Berenth Nielsen**
  University of Southern Denmark (Denmark), Chief Innovation Officer, former Cluster manager Innovation Network RoboCluster. Face-to-face meetings at the ERF23 16 March 2023 in Odense (Denmark) and at the University of Twente 26 April 2024 in Enschede (Netherlands). linkedin.com/in/mortennielsenfab
- **Maurits Butter**
  TNO (Netherlands), Senior scientist TNO strategy & policy, involved in several relevant European projects such as RODIN, RI4EU and DIHnet. Discussions at the RODIN meeting 9 September 2022 in Oslo (Norway) and the 2nd ICT-48 VISION event 19 October 2022 in Brussels (Belgium). linkedin.com/in/maurits-butter-6110561

- **Renaud Champion**
  PrimNext (France), CEO, Investor, Member Board of Directors Adra (at the time of the interview). On-line interview February 2023. linkedin.com/in/renaud-champion-2638b71b

- **Jesus Contreras**
  EIT Digital (Spain), Digital innovation director. Face-to-face discussions at the EIT Digital meetings on 1 June 2022 and 6 June 2023 in Brussels (Belgium). linkedin.com/in/jcontreras

- **Thomas Hahn**
  Siemens AG (Germany), Chief expert software, President Big Data Value Association (BDVA) one of the founding organizations of Adra, Member of Board of Directors Adra (at the time of the interview). On-line interview on 31 October 2022. linkedin.com/in/hahn-thomas-23051695

- **Willem Jonker**
  AIC4NL (Netherlands), Professor, Chairman of the Board of AIC4NL (AI Coalition4Netherlands), previous Chairman of the Board of AiNed, previous CEO of EIT Digital. Face-to-face meeting at the University of Twente in Enschede (Netherlands). linkedin.com/in/willem-jonker-4a8aa3b0

- **Reinhard Lafrenz**
  euRobotics (Belgium), Secretary-General euRobotics aisbl (one of the founding organizations of Adra). Face-to-face discussion at the RODIN meeting 9 September 2022 in Oslo (Norway) and during the ERF23 event 15 March 2023 in Odense (Denmark). linkedin.com/in/reinhard-lafrenz-658b6317

- **Christophe Leroux**
  CEA-List (France), Manager European Affairs in AI and robotics, Member Board of Directors euRobotics, Member Board of Directors Adra. Face-to-face discussions at the ERF23 event March 2023 in Odense (Denmark) and several Adra and Adra-e meetings in Brussels (Belgium) and Paris (France). linkedin.com/in/christophe-leroux-0324274

- **Kirke Maar**
  EDIH AIRE (Estonia). Manager European Digital Innovation Hub AIRE (AI & Robotics Estonia). Face-to-face discussion at Techtal in Tallinn (Estonia). linkedin.com/in/kirke-maar-6b8a835

- **Federico Menna**
  EIT Digital (Italy, Belgium), Chief Executive Officer EIT Digital. Face-to-face discussions at the EIT Digital events on 1 June 2022 and 6 June 2023 in Brussels (Belgium) and at the ADRf23 8 November 2023 in Paris (France). linkedin.com/in/federicomenna

- **Petri Myllymaki**
  University of Helsinki (Finland), Professor, Director Helsinki Institute for Information Technology, Vice director Finnish Center for AI, Director External Relations ELLIS (European Laboratory for Learning and Intelligent Systems), Member Board of Directors Adra, Member UN High-Level Advisory Body on AI. Online interview March 2023 and several face-2-face discussions during Adra meetings in Brussels in 2022. linkedin.com/in/petrimyllymaki

- **Philip Piatkiewicz**
  Adra (Belgium). Secretary-General Adra. Face-to-face discussions during several Adra and Adra-e meetings in Brussles (Belgium) and Paris (France) in 2022 and 2023.

linkedin.com/in/philip-piatkiewicz-8a337644

- **Francoise Siepel**
  University of Twente (Netherlands), Adjunct Professor, Head DIH-HERO (Digital Innovation Hubs on Healthcare Robotics, Coordinator Adra Topic Group ADR for Healthcare. Several face-to-face discussions at the University of Twente in Enschede (Netherlands). linkedin.com/in/françoise-siepel-583995168

- **Caj Södergård**
  NextAI (Finland), Member Board of Directors BDVA, at the time of the interview Member Board of Directors Adra. Several face-to-face discussions during Adra and Adra-e meetings in Brussels and Paris in 2022 and 2023. linkedin.com/in/caj-södergård-61b2b

- **Maarten van Steen**
  University of Twente (Netherlands), Professor, Scientific director Digital Society Institute, Member Advisory Board of AICoalition4NL. Face-to-face discussion at the University of Twente in Enschede (Netherlands). linkedin.com/in/maarten-van-steen-42a998ba

- **Stefano Stramigioli**
  University of Twente (Netherlands), Professor, Member Board of Directors and Vice President Research euRobotics and Member Board of Directors and Vice President Research Adra (at the time of the interviews), former director iBotics, former chair RoboNed. Several face-to-face discussions at the University of Twente in Enschede (Netherlands). linkedin.com/in/stefano-stramigioli-32b4892

- **Aksel Transeth**
  SINTEF Digital (Norway), Senior scientist, Chair RIMA Alliance (Robotics for Maintenance and Inspection), Coordinator Adra Topic Group ADR for Inspection and Maintenance. Face-to-face discussions during the ERF23 event 15 March 2023 in Odense (Denmark). linkedin.com/in/aksel-transeth

## 4.3 WORKSHOPS AND EVENTS

To foster the dialogue between approaches and initiatives and to increase the joint knowledge about useful instruments for ADR technology adoption, workshops were organized during events of Adra (e.g. its ADR forum event in 2023 and 2024 and Adra's Future Ready event in 2025), the yearly event of the Adra founding organization euRobotics (European Robotics Forum ERF in 2025), and several events organized by Adra-e. Next to these workshops, Task 4.4 also actively participated in a couple of other events organized by the ADR community.

The workshops started with several short inspiring presentations of different regional and national 'best practices' to learn from. Many of these examples were selected based on the earlier performed interviews and literature studies. During the workshops, these inspiring presentations served as input and stimulated the discussion about national and European instruments to stimulate ADR uptake and adoption. Most workshops had between 20 and 50 participants, comprising a very diverse group of researchers, entrepreneurs, representatives from regional and national governments, and intermediary organizations. With more than 20 participants, the group was split into two for the interactive discussion part. The main findings were then shared in the plenary session.

Additionally, several workshops concentrated significantly on the European innovation instruments available and their potential impact and role in regional innovation systems, as it is important for regional and national actors to be aware of the available European innovation instruments. Not only to utilize these instruments, but also to align their own innovation instruments with them to develop the national and regional ecosystems as effectively as possible.

Task 4.4 delved into the reasons behind the effectiveness of regional or national innovation models and explored the lessons they can learn from each other. There's a clear connection between these activities and the mapping and cartography initiatives undertaken in various other projects. The European Commission has assigned VISION and several European Networks-of-Excellence the task of mapping the capabilities and competencies within the European AI ecosystem. The Adra-e Task 2.1 also focuses on mapping and collaborates closely with VISION. Furthermore, the AI-on-Demand platform can play an important role in facilitating integration and access. These mapping activities provide valuable data, such as identifying the key players and their locations, quality, and output. This fundamental data information is important for Task 4.4, which primarily focused on identifying the type of regional, national, or European innovation instruments and initiatives contributed to the success of ADR ecosystems, exploring the role of governments at both regional and national levels, etc. Therefore, workshops also frequently involved collaboration with the more ecosystem-mapping-oriented activities within the ADR community.

Workshops organized by T4.4 and several other events of the ADR-community with contributions of T4.4 are presented below.

**A. AI-Data-Robotics forum 2023 (ADRf23)**
Versailles (France), 8-9 November 2023.

Workshop 10 organized by Iddo Bante (UTwente) and Christophe Leroux (CEA): '***Innovation, deployment, and uptake of ADR technologies – offer from the instruments supported by the EC'***.
Website: https://2023.adrforum.eu/innovation-deployment-and-uptake-adr-technologies-offer-instruments-supported-ec

This 1h30 workshop aimed at initiating the Adra Topic Group on Innovation, deployment and uptake of ADR technologies. The workshop's objective was to explore how various European instruments could be utilized to support the ADR innovation, uptake, and adoption activities of Adra members. Additionally, it aimed to determine how these instruments could complement existing instruments of different European member states.

The workshop was divided into two parts: the first part featured presentations of experiences with the European instrument in supporting innovation, deployment, and uptake of ADR technologies. The second part was a panel discussion on how to stimulate interactions between these instruments and the Adra community.

Innovation leaders working with various innovation instruments of the European Commission in the H2020 and HE periods shared their practical experiences. The concepts of Digital Innovation Hubs (DIHs), particularly those focused on specific technologies like AI (DIH4AI) and robotics (DIH RIMA), were discussed and compared with the new EDIH concept (European Digital Innovation Hubs), which aims to support the adoption of

digitalization and ADR technologies in regions, industry, and the public sector. The added value of the TEF concept (Test and Experimentation Facilities for AI) was explained and discussed. Additionally, the role of EIT instruments in the uptake and deployment of advanced digital technologies was highlighted, and the experiences of the ETAPAS initiative to facilitate the uptake of advanced digital technologies in the public sector were discussed.

The following presentations formed the inspiration basis for the subsequent discussion. Three of the presentations are available for download or by clicking on the links below.


- Workshop Innovation, deployment and uptake of AI-Data-Robotics technologies - Christophe Leroux (France) and Iddo Bante (Netherlands)
- DIH4AI, DIH network on uptake of AI - Sergio Gusmeroli, Poli Milano (Italy)
- ETAPAS, AI uptake by public sector, Giovanna Galasso, Intellera (Italy)
- European robotics networks of DIHs - Reinhard Lafrenz, euRobotics (Belgium)
- The EDIH concept, Yves Paindaveine, European Commission, DG CNECT (Belgium)
- AgRoboFood, network of DIHs for agrifood - Farzam Ranjbaran, CEA-List (France)
- DIH-HERO, European network of DIHs for healthcare robotics - Françoise Siepel, University of Twente (Netherlands)
- TRINITY, European network of manufacturing DIHs - Minna Lanz, University of Tampere (Finland)
- RIMA Alliance, European network of DIHs for Inspection and Maintenance - Aksel Transeth, SINTEF (Norway)
- EIT Digital, Iddo Bante – University of Twente (Netherlands)
- TEF on Manufacturing - Valentina Ivanova, CEA-List (France)

After the presentations, the panel (all presenters) discussed with the workshop participants questions such as: What support can these instruments provide to Adra and its members? How can Adra leverage its expertise? What is the role of the member states? What innovation support can/should Adra offer to its members? How can Adra organize its interactions with these networks?

This workshop demonstrated the distinct approaches of the new EDIH concept and the existing European Digital Innovation Hub (DIH) networks such as DIH-HERO (Digital Innovation Hub network for Healthcare Robotics), DIH RIMA (DIH network for Robotics in Inspection and Maintenance), TRINITY (DIH network focused on the manufacturing sector), and AgRoboFood (DIH network for robotics in the AgriFood domain). These existing European DIH networks primarily concentrate on innovators and early adopters, encompassing the entire application-domain-specific innovation chain across Europe. While there are numerous regional tech providers, fewer tech integrators, and, particularly in sectors like healthcare, even fewer companies that supply end products, domain-specific laws and regulations, and national health reimbursement systems play a crucial role. In

contrast, the new EDIHs are more generic, place a stronger emphasis on regional businesses, and offer relatively less attention to specific application domains with their specific requirements and international innovation chains. The European Test and Experimentation (TEF) model offers promising opportunities. For European instruments such as EDIHs and TEFs, national choices and co-funding are crucial. Some countries are clearly more capable of achieving this than others.

Workshop 1 '***Towards a mapping of the AI-Data-Robotics ecosystem***' was co-organized by Anne Bergen (UT), in close cooperation with the European Vison project and Adra-e WP2 Task 2.1. An integrated overview of European research, development, and innovation activities in the field of ADR is lacking. The European Commission has tasked VISION and several Networks-of-Excellence (AI4Media, ELISE, HumanE-AI-Net, TAILOR, ELSA, and euROBIN) with mapping the capabilities and competencies within the current AI ecosystem. A first version of an interactive website, focusing on the AI subset of the ADR ecosystem, is now available. Anne Bergen presented (presentation is available for download) relevant Adra-e activities and provided an overview of the broader ADR spectrum of European innovation instruments and initiatives.

During the workshop, options for future collaboration with other activities such as Adra-e and the AI-on-demand platform were explored. It became evident that the data generated by European mapping activities regarding the capabilities and competencies within the European ADR ecosystem could serve as valuable input for Task 4.4, while this task primarily focuses on identifying the factors contributing to the effectiveness of regional or national innovation models and the lessons that regions and member states can learn from each other.

Task 4.4 also contributed to Workshop 13 '***Adra Topic Group Healthcare: Data AI Robotics embedded in the healthcare sector: what are the needs to be fulfilled***?', coordinated by Francoise Siepel (UT). Adaption and innovation of ADR technologies require network building and connectivity among various stakeholders, encompassing a diverse range of actors spanning the entire innovation chain along the continuum of healthcare pathway (specialized intervention in hospitals – lightweight care at home). Success stories, challenges and domain-specific European innovation instruments related to the adoption and deployment of ADR in the healthcare sector were presented and discussed. This sector necessitates diverse domain-specific approaches and tools, as, for instance, legislation and health insurance policies often vary across European member states.

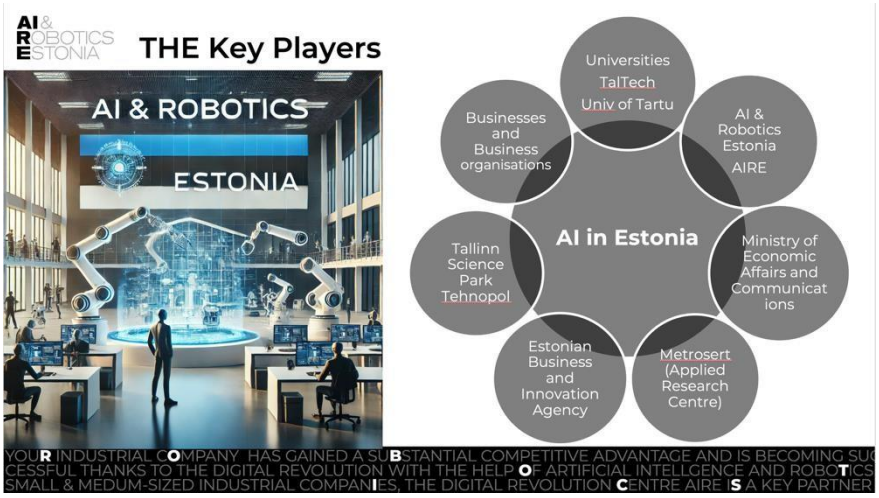
This workshop demonstrated the added value for adoption of ADR technologies in the healthcare sector of domain knowledge (such as legislation, standardization, reimbursement systems) and it underscored the importance of strong connections to key stakeholders in the application-domain specific innovation chain across Europe.

Task 4.4. also contributed to the ADRf23 workshop '***Enhancing Responsible Robotics in Europe***'. Responsible AI and responsible robotics are important for the social acceptance and adoption of these technologies. Philip Brey (UT) shed light on the distinction between responsible robotics and responsible AI in his presentation. His presentation is available for download.


Adra, a young and developing organization, can gain valuable insights from more established European organizations. Strategic partnerships enable Adra to provide certain services to its members more efficiently. ***EIT Digital***, a 15-year-old European organization with a strong emphasis on innovation and technology adoption, and start-up & scale-up support, has established co-locations in many different European member states. This facilitates strong interactions between regional and national requirements and European opportunities. Therefore, a Memorandum of Understanding (MoU) was signed during the ADRf23 to foster cooperation in the innovation sector between Adra and EIT Digital. Task 4.4 (Iddo Bante, UT) actively supports this collaboration, including regular joint taskforce meetings between Adra and EIT Digital.

**B. EIT Digital – AI and robotics innovation ecosystem in Estland**
Tallinn (Estonia), 12 December 2023.

In November 2023, Adra and EIT Digital signed the Memorandum of Understanding. In December, the Supervisory Board of EIT Digital visited their new co-location and several regional innovation partners in Tallinn (Estonia). During this visit, Task 4.4 (Iddo Bante, UT) presented and discussed the development of the ADR innovation ecosystem in Estonia with representatives from Taltech (Tallinn University of Technology) and EDIH AIRE (AI & Robotics Estonia). The EDIH in Tallinn not only serves the region, but is the Innovation Hub in the field of AI and robotics for the entire country. AIRE recognized the advantages of Adra's extensive European network and activities and decided to join it. Later, during an ADRf24 workshop, AIRE further explained Estonia's national AI strategy.



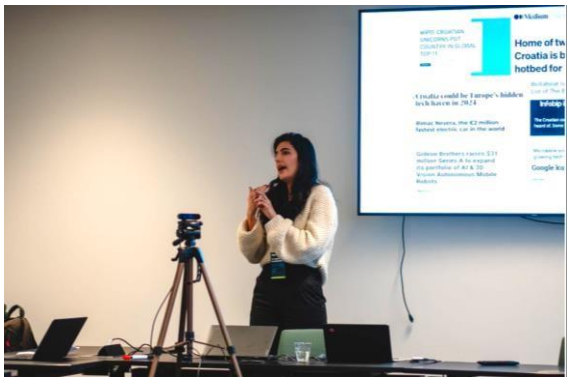
**C. 2nd ICT-48 Community event VISION 'Towards a shared European AI map and Strategic Research Agenda'.**

Brussels (Belgium), 19 October 2022.
Website: https://www.vision4ai.eu/ict48-community-workshop-2022

The afternoon workshop was designed for the AI Research & Innovation community of the European projects VISION, ELISE, AI4Media, ELSA, TAILOR, HumanE-AI-Net, euROBIN, AI4Europe, and Adra-e, particularly the ICT-48 project coordinators, WP-leads, and representatives of the European Commission.

During the workshop, Maurits Butter (TNO) and Iddo Bante (UT) presented a 65-minute joint RODIN/Adra-e presentation titled "The challenges of information infrastructure and capacity mapping: Lessons from RODIN and Adra-e." This presentation involved active audience participation. The diverse contacts and discussions during this event, which included a wide representation of the European AI community, provided valuable input, insights and recommendations for both Task 2.1 and Task 4.4 of Adra-e. A download of the presentation is available.

**D. AI Regional Ecosystems event Amsterdam**
Amsterdam (Netherlands), 8 February 2024.
Website: https://adra-e.eu/events/ai-regional-ecosystems-leading-ai-building-public-private-partnerships.



Task 4.4 was involved in this conference organized by Adra-e WP4 Task 4.3 in two ways: First, Iddo Bante (UT) delivered a keynote presentation titled '***Building blocks for ADR innovation ecosystems***', followed by a discussion. The presentation is available for download. Secondly, Anne Bergen (UT) organized a workshop titled *'**AI ecosystem collaboration, examples of the Netherlands and Croatia**'*.

The event aimed to facilitate collaborative discussions on the transformative and critical role of public-private partnerships in fostering innovation within the European AI landscape. Leading experts from industry, Digital Innovation Hubs, and government engaged in discussions, highlighting the significance of public-private partnerships in funding AI innovation. They shared valuable insights and experiences on how these collaborations can drive technological advancements, foster economic growth, and promote the responsible development of AI solutions. A comprehensive report of the event is available in the Deliverable 4.3 'Regional Ecosystems Report'.

During the workshop, best practices from two different national AI ecosystems - Netherlands and Croatia - were discussed by Martina Silov (President of the Croatian Association for Artificial Intelligence, CroAI) and Cees Snoek (Scientific Director Amsterdam AI). Both presentations are available for download at Amsterdam AI and CroAI.

The primary objective was to explore two successful ecosystems and to identify the prerequisites for establishing a successful ecosystem, including the instruments they use as well as the strategies to achieve a critical mass. Through an interactive discussion with the audience, it was discussed what distinguishes an effective AI ecosystem.

The presentation about Croatia focused on establishing CroAI to create a robust AI ecosystem, and the establishment of the European AI Forum to foster dialogue between policymakers who lack technical expertise and the tech community who lacks understanding of laws and policies. CroAI's community building pillar involves organizing conferences and meetups that bring together individuals from diverse backgrounds and perspectives,

including photographers, artists, doctors, politicians, and ministers. Today, Croatia has a well-connected vibrant AI ecosystem.

Amsterdam is the only Dutch city with two universities. It has the largest Dutch polytechnic university, two academic hospitals, the National Cancer Institute, the blood knowledge institute, the national research institute for mathematics and computer science, an AI-interested municipality, and an Economic Board recognizing AI's economic potential. Despite occasional competition for funding and talent, recently these institutions have joined forces in 'Amsterdam AI' to expand the AI 'pie'. Amsterdam combines deep technical knowledge from various institutions with a broad societal use of AI. This combination is not found in many places in Europe. Amsterdam AI has a multitude of ICAI Labs (Innovation Centers for AI) in their network as well as Ethical, Legal and Societal Aspects (ELSA) labs.

**E. European Convergence Summit 2024 (ECS24) - Impact of AI, Big Data and Robotics on $CO_2$ reduction**, online streamed from Brussels (Belgium).
Website: https://adra-e.eu/events/european-convergence-summit-2024


The ECS brings together influential figures from various backgrounds to support co-programming of the ADR partnership, define orientations for European ADR research and innovation with respect to socio-economic issues, and build a consensus among stakeholders. The theme of the ECS24 was the impact of ADR on energy / $CO_2$ reduction. The event was organized in three blocks: (1) European ADR strategies, (2) ADR and Environmental Issues, and (3) Public Involvement and Normative Issues.

T4.4 (Iddo Bante, UT) contributed to this event organized by Adra-e WP4 T4.1 by chairing the Insight Panel, which focused on the future promising path and the implementation and adoption of ADR technologies for $CO_2$ reduction.

**F. EIT Digital Investor Brunch** (side-event of the ADRf25).
Eindhoven (Netherlands), 4 November 2024.
Website: https://www.eitdigital.eu/newsroom/events/2024/european-ai-data-robotics-forum-investor-brunch-side-event/

Several interviews and workshops had revealed that access to financing is often a barrier to further business growth, especially when the company is relatively young and small. Organizing access to capital is a crucial building block for innovative regions, countries, and their ecosystems. For companies with growth ambitions, access to internationally operating investors is particularly important.

EIT Digital, with which Adra has entered into a Memorandum of Understanding (MoU) for cooperation, boast an extensive network of European investors, and they know their technology expertise, domain knowledge and interest, and country focus. The Investor Brunch, an exclusive side event organized by EIT Digital prior to the ADRf24, offered a great opportunity for start-ups with serious growth potential to pitch their company to a group of

experienced European investors. The matchmaking and pitching event, designed to connect investors and start-up and scale-up companies in the ADR domain, was a joint initiative of Adra, EIT Digital, the Dutch Top Sector ICT, AiNed and Adra-e Task 4.4 (Iddo Bante, UT).


The participating companies met the following criteria: their core technology was ADR, they were in the early growth stage and ready for series A funding, they were already active in the market with a clear commercial turnover, and they had a minimum of 5 FTE.

During 10-minute round table pitch-sessions with built in Q&A, 18 promising start-ups and scale-ups had the opportunity to introduce their vision, products and growth strategy, to engage with 12 investors from across Europe specialized in the ADR domain. The sessions were designed to stimulate focused introductions and rapid networking. During the subsequent informal networking brunch was plenty of room for further networking, deepening conversations, and forging potential valuable partnerships with industry innovators and investors in a relaxed setting.

The agenda of the Investor Brunch was:

| | |
|---|---|
| 09:30-10:00 AM | Welcoming reception, giving a chance to settle in and start conversations over coffee. |
| 10:00-10:50 AM | Pitching Session Round 1 |
| 10:50-11:10 AM | Break |
| 11:10-12:00 PM | Pitching Session Round 2 |
| 12:00-12:30 PM | Decompression time, a moment to unwind, relax and reflect on the connections made. |
| 12:30 PM | Networking lunch |

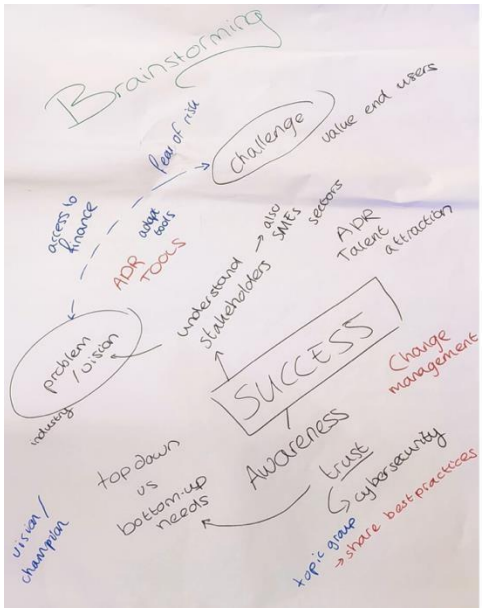
Most companies were approached directly by EIT Digital and various Adra member organizations. An example of the announcement via internet is available at https://ained.nl/en/investors-brunch-meld-je-aan-voor-een-exclusief-evenement-voor-startups-en-scale-ups/

**G. AI-Data-Robotics forum 2024 (ADRf24)**
Eindhoven (Netherlands), 4-5 November 2024.

Workshop organized by Iddo Bante (UT) on November 4, 2025: '***Shaping the new Adra Topic Group 'Innovation, deployment and uptake of ADR technologies***.'
Website: https://adrforum.eu/shaping-new-adra-topic-group-innovation-deployment-and-uptake-adr-technologies

The workshop was the kick-start of the new Adra Topic Group titled 'Innovation, Deployment and Uptake of ADR technologies'. The objectives were to officially launch the Topic Group, disseminate the latest developments, gather grassroots input from the ADR community, as

well as to set the priorities of the Topic Group for the near future. Additionally, the workshop aimed to initiate a comprehensive discussion on successful and inspiring best practices at regional, national, and European levels. The Topic Group builds upon numerous existing ADR innovation initiatives and serves as a gateway to the most significant national and European innovation activities with the aim to foster the adoption of ADR technologies. The Topic Group aims to become a creative and inspiring platform that generates innovative proposals for Adra and its members, member states, and regions.




During the workshop, several successful regional and national ADR-approaches and European instruments such as (E)DIHs, TEFs and EIT Digital were presented. The following presentations highlighted successful approaches for innovation, adoption and uptake of ADR technologies and formed the inspiration basis for the subsequent interactive round table discussion. Click on the links below to download the presentations.

- Mission and vision of the topic group; Iddo Bante, University of Twente (Netherlands)
- Comparison of AI-strategies in Finland, Sweden and the Netherlands; Claudio Lazo, TNO (Netherlands)
- Regional Innovation for ADR technologies adoption: the EDIH Lombardy experience in Manufacturing Industry; Sergio Gusmeroli, Politecnico di Milano (Italy)
- Regional ADR ecosystem in Estonia; Katre Elias, EDIH AIRE (Estland)
- ADR-based innovation in the Healthcare domain; Francoise Siepel, University of Twente and coordinator of the Adra Topic Group Healthcare (Netherlands)
- European innovation ecosystem EIT Digital; Jesus Contreras, EIT Digital (Spain).

Due to the large number of participants, the group was split in two, after which the discussions took place under the guidance of Christophe Leroux (CEA, France) and Anne Bergen (UT). Some question discussed were:

- What are the lessons-learned and best practices for ADR-adoption on a regional, national and EU level?
- Which generic innovation tools and which AI-Data-Robotics specific innovation instruments are needed?
- What should be organized bottom-up by regions and member states, and what top-down by the European Commission?
- What would you like the Adra Topic Group to do to stimulate innovation activities, and how do you like to be involved?

Lazo's presentation was received as particularly intriguing, as it delved into the disparities between the national AI strategies of the Netherlands, Finland, and Sweden. For instance, in the Netherlands, existing innovation instruments were utilized, a departure from the approach adopted in several other countries. The Netherlands opted for a consensus-building approach involving numerous stakeholders, while Finland chose a more rapid top-

down approach centered around scientific excellence. In Estonia there is no distinction between the regional and national AI and robotics approaches; they flow seamlessly into each other. The EDIH AIRE in Tallinn has a national role.

Contreras presented one of the EIT Digital initiatives in Silicon Valley to attract more talents to Europe. Francoise emphasized that for successful innovation, ADR adoption, and economic and social impact creation require, in addition to generic innovation instruments, domain knowledge and application domain-specific tools.

Access to funding was also an important topic during the discussion. Aksel Transeth highlighted the challenges faced by SMEs in securing funding and connecting with the appropriate investors. He emphasized the need to differentiate between funding for innovation and uptake and funding for market development. Contreras concurred that the investments in Europe are significantly lower compared to the USA. He suggested to identify the right European niches and adopt a bottom-up approach to address this issue. European fragmentation was also mentioned several times, and the need for a strong European innovation network was highlighted. It was agreed that Adra can play a significant role in this regard.

Task 4.4 was also involved in another ADR24 activity. On November 5, 2025, Anne Bergen (UT) was co-organizer of the workshop titled '***Mapping the European AI ecosystem – state of play and next steps***'. The primary organizers of this workshop were the Adra-e Task 2.1 together with representatives of the European Vision and AI-on-demand projects. The main objective of this meeting was to kickstart the Adra joint topic group focused on Ecosystem Mapping & Information Repository (EMIR). Partners from various EU initiatives, including Adra-e, the AI-on-demand platform, and the European network of AI excellence centers, had come together to form EMIR. The workshop served as an opportunity to inform the ADR community about the latest developments, gather feedback, ideas, and suggestions, and establish priorities for the near future. The presentations are available for download.

Again, it appeared that the data gathered from various European ADR mapping initiatives could be valuable input for Task 4.4, which is primarily focuses on identifying the factors contributing to the effectiveness of regional or national innovation models and the lessons that regions and member states can learn from each other.

**H. AI Regional Ecosystem event Zagreb**

Zagreb (Croatia), 12 November 2024.
Website: https://www.adr-association.eu/events/regional-ecosystem-event-2024


The second Regional Ecosystems Event of Task 4.3 was held in Zagreb, Croatia, with the support of Task 4.4. Since the Adra-e partner CroaAI is involved in both tasks, Lorena Baríc and Martina Silov of CroaAI were able to seamlessly integrate the event.

The event aimed to highlight the unique strengths, potential, and collaborative spirit of the Central and Eastern European (CEE) tech ecosystem, particularly Croatia. It showcased the region's tech innovation, including AI and robotics, as well as its policy-making capabilities. The event fostered vital cross-border collaboration by connecting visionaries and decision-makers. It clearly demonstrated the growth and global scale competitiveness of the CEE ecosystem over the past few years. The outcomes of this event are presented in Deliverable D4.5.

**I. AI in Robotics event: Inspiration and innovation in Agriculture and Healthcare**
Enschede (Netherlands), 28 November 2024.
Website: AI in Robotics event: Inspiratie en innovatie in Landbouw en Zorg

This event, organized in collaboration with the AI Hub of East Netherlands, brought together the robotics and AI communities from two key sectors: agriculture and healthcare. By focusing on regional partners, the event fostered cross-sector inspiration and collaboration, helping to identify shared challenges in adopting autonomous decision-making and robotics (ADR). Discussions revealed that similar technologies—such as agricultural field robots—could be repurposed for logistical tasks in healthcare. However, the event also underscored the importance of addressing ethical and human-centered considerations. Moreover, it highlighted the need for accessible, low-threshold funding to encourage regional stakeholders, particularly SMEs, to pursue innovation.

**J. Future Ready: on-demand solutions with AI, Data, and Robotics**
Brussels (Belgium), February 18-19, 2025.
Website: https://adr-association.eu/events/future-ready-demand-solutions-ai-data-and-robotics


This event was organized by AI-on-Demand and Adra and supported by AI4Europe and Adra-e. It aimed to bring together the ADR partnership projects launched in 2022 and 2023. It showcased project results, discussed challenges, and explored opportunities for future collaboration. A special focus was placed on engaging with Adra Topic Groups, which unite diverse stakeholders around shared areas of interest, and the connection with the AI-on-Demand platform.

The second day of the event was dedicated to the Adra Topic Groups. The workshop titled '***Innovation, uptake and deployment of ADR / EMIR'*** was a joint activity of the Adra Topic Group 'Innovation, uptake and deployment of ADR technologies' (organized by Task 4.4, Iddo Bante of UT) and the Adra Topic Group 'Ecosystem Mapping & Information Repository' (EMIR, with support of Adra-e Task 2.1). This

collaborative approach resulted in a lively discussion on mutual reinforcement and cooperation. The presentation is available for download.

**K. European Robotics Forum 2025 (ERF25)**
Stuttgart (Germany), 25-27 March 2025.
Website: https://erf2025.eu

The European Robotics Forum (ERF) is the main event of the European Robotics Association euRobotics, one of the founding fathers of Adra. The Forum serves as the pinnacle of robotics in Europe. The 2025 theme, "Boosting the Synergies between Robotics and AI for a Stronger Europe," aims to bring together researchers and industry stakeholders, present the current state of robotics and AI on a large scale, and shape future technological developments. With over 1,300 participants from European industry, academia, and politics, and an extensive program on robotics and AI, the forum aims to foster interaction between end users, researchers, and technology producers, ultimately leading to improved industrial competitiveness, scientific progress, enhanced networking among stakeholders in this field, and the identification of new application scenarios for robotics.

Task 4.4 organized two workshops during the ERF25. The first workshop, coordinated by Iddo Bante (UT) on March 25, was titled "***How can European regions stimulate innovations in robotics?***"


Goal of the workshop was to inspire, discuss and deepen joint understanding of regional and national innovation strategies: knowledge exchange and insights in how different innovation instruments & strategies can stimulate innovation with and adoption and uptake of robotics technologies. The workshop explored how regional innovation initiatives drive the adoption of robotics technologies across Europe. Experts discussed successful approaches, key enablers, and stakeholder roles in fostering innovation. The session highlighted best practices from leading regions and initiatives, emphasizing impact, scalability, and cross-sector applications.

The workshop started with six short pitches, followed by interactive discussions with participation of all attendees about the lessons learned, best practices, take-away messages. The core program was:

Short pitches on inspiring successful regional innovation approaches stimulating robotics technology uptake:

- UK's new R&D funding agency ARIA Smart Robot Bodies program: Jenny Read, Gudipati, ARIA (UK)
- Odense Robotics Region: Morten Berenth Nielsen, Southern Denmark University (Denmark)
- Twente Robotics: Iddo Bante, University of Twente (Netherlands)
- RoX Digital Ecosystem for AI-based robotics: Felix Spenrath, Fraunhofer (Germany)
- Robotics Institute Germany (RIG), Tamim Asfour, IAR (Germany)

- DIH4CAT: Managing Robotics Innovation in the region Barcelona: Daniel Serrano, Eurocat (Spain)

Panel session with active audience involvement. The initial questions of this dynamic discussion were:

- What makes these examples successful?
- What are crucial tools, instruments, and methodologies driving regional innovation in robotics (e.g. test facilities, access2funding)?
- What are the roles of regional and national stakeholders?
- What are the different needs/approaches per application domain (e.g. healthcare, agrifood, manufacturing)?

The outcome was a deeper understanding on how to enhance robotics innovation processes in other European regions and countries. Especially, the recent developments in the UK (new R&D funding agency) and Germany (establishment of the new Robotics Institute Germany) drew the attention of several participants. It was also gratifying to observe that representatives of the German Ministry of Economic Affairs made follow-up appointments with some workshop presenters.

The second workshop organized by Task 4.4, coordinated by Iddo Bante (UTwente) together with Christophe Leroux (CEA), was titled '***European innovation structures and networks'***. Website: http://erf2025.eu/programme/#detailed

Goal of the workshop was to inspire, discuss and deepen joint understanding of the European Innovation instruments and insights in how they can help SME's with their robotics technology-based innovation and market uptake. Important questions were: What is the role of the innovation structures and networks? How can the challenge of technology transfer be addressed? The workshop explored how European innovation instruments and networks drive the adoption of robotics technologies across Europe. The session highlights best practices and initiatives, emphasizing impact, scalability, and cross-sector applications. The intended outcome was a better understanding of European instruments and how they can foster innovation and adoption of robotics technology.

The program of the workshop was:

Overview European Instruments: Iddo Bante, University of Twente (Netherlands)

Inspiring pitches:

- EDIH Test-before-Invest: Christian Wogerer, EDIH AI5Production (Austria)
- TEF Test and Experimentation Facilities: Raffaele Giaffreda, AgrifoodTEF (Italy)
- SME Funding: Jesus Contreras, EIT Digital (Spain)
- Regional innovation with EDIH: Ernest Clark Fuller, EDIH Odense (Denmark)
- Innovation Networks of euRobotics: Francoise Siepel, DIH-HERO (Netherlands).

Panel session (moderator was Christophe Leroux of CEA in France) with active audience involvement discussing questions such as:

- What does and what doesn't work?
- How can European instruments support technology transfer challenges to enable commercialization of robotics technologies?
- What are the interactions between European instruments and regional/national robotics communities? How can we organize the interactions between these networks?
- What other European instruments are needed?

EDIHs (European Digital Innovation Hubs) and TEFs (Test and Experimentation Facilities) are useful European instruments to stimulate innovation in European regions. The strong connection between the TEF and EDIH in Odense particularly caught the audience's attention as a very efficient way of working, serving as a comprehensive one-stop-shop model for SMEs. Furthermore, the European EIC (European Innovation Council) and EIT Digital instruments align seamlessly with the needs of SMEs regarding access to finance; the ecosystem-based approach of EIT Digital offers a distinct advantage in this regard. It was also evident that, in addition to the more generic approach of EDIHs, SMEs require more application-domain-specific support and instruments that enable them to effectively participate in Europe-wide innovation chains.

**L. European Convergence Summit 2025 (ECS25) - Resilience in case of crisis**
Brussels (Belgium), 9 April 2025.
Website: https://adr-association.eu/events/european-convergence-summit-ecs-2025

ECS evens aim to identify how AI, robotics, and big data can collaborate to address socio-economic issues of interest to Europe, its citizens, and its economy. Following the first online ECS24 edition, the one-day in-person ECS25 event focused on European resilience in case of crises. The ECS25 brought together diverse perspectives from representatives of industry, research and innovation, civil society, legal, ethical, regulatory, and public policy experts. The ADR approaches to tackling these challenges presented and discussed during the event can be adopted by the Adra partnership.

T4.4 (Iddo Bante, Francoise Siepel, Maren Bödding, Willem Jonker, UT) contributed to this event organized by Adra-e WP4 T4.1 by being a member of the program committee, chairing the panel discussion 'ADR for resilience in European Healthcare', giving the keynote 'Future directions in AI, data and robotics', and by chairing the Insight Panel discussion focused on the implementation and adoption of ADR technologies to increase European resilience in healthcare, industrial production, civil security and defense. The event and it's outcomes are described in detail in Deliverable D4.2.


**M. AI-Data-Robotics forum 2025 (ADRf25)**
Stavanger (Norway), 23-24 Sept. 2025

Workshop to be organized by Iddo Bante (UT): '***Creating Impact: Innovation, deployment, and uptake of ADR technologies***'. Although this workshop has not been held at the time of writing this report, the proposal for it has been granted by the ADRf25 program committee.


Over 17 interviews and discussions with stakeholders from exemplary ecosystems were conducted to explore European AI-Data-Robotics innovation approaches and regional and national best practices. To facilitate dialogues among stakeholders in the ADR ecosystem and enhance collaborative knowledge about regional and national innovation strategies, as well as the added value of national and European instruments in stimulating ADR adoption, over 17 interactive workshops and presentations were (co)organized during various events hosted by key players in the ADR community, including Adra (ADRf, Future Ready), euRobotics (ERF), Adra-e (ECS), and VISION. The workshops inspired academic researchers to adopt a more entrepreneurial mindset, provided companies with insights into the available national and European innovation instruments and their added value, and fostered knowledge exchange with ecosystem builders and representatives from regional and national governments.

Adra has been supported in establishing the Topic Group titled "Innovation, Deployment, and Uptake of ADR Technologies." The Task lead has been appointed as coordinator and several individuals who have actively contributed to workshop discussions have become members. As a result, the activities and accumulated knowledge related to this Adra-e task are seamlessly integrated into this Adra Topic Group. The continuation is visible as the proposal for the workshop "*Creating Impact: Innovation, Deployment, and Uptake of ADR technologies*" during the upcoming ADRf25 has been approved, while an invitation has been received to submit a workshop proposal for the ERF in 2026.

Together, these efforts have laid a strong foundation for sustained collaboration, knowledge sharing, and strategic action to accelerate the responsible deployment and adoption of ADR technologies across Europe.

## 4.4 NATIONAL AI STRATEGIES

*This chapter explores current trends and developments in national AI strategies. In recent years, the growing importance of AI has prompted many countries to formulate dedicated strategies and programs. This section gives an overview of key trends, including AI strategies in low- and middle-income countries, emerging patterns in regulation and legislation, differing national approaches, the Government AI Readiness Index, international collaboration on AI, and various aspects of AI policy design and implementation.*

*To remain competitive in a rapidly evolving global landscape, Europe must significantly increase its investments in AI while upholding its core values of trust, ethics, and human-centric governance.*

### 4.4.1 INTERNATIONAL DEVELOPMENTS

AI's influence on society has never been more evident. It is increasingly embedded in everyday life and is ready to become the most transformative technology of the 21st century. From the laboratory to our daily routines, from healthcare to transportation, AI is making rapid strides. In 2023 for example, the FDA approved an impressive 223 AI-enabled medical devices, a significant increase from just six devices in 2015. And self-driving cars have left the realm of experimentation with hundreds of thousands autonomous rides each week (*Maslej et al, 2025*).

As we are on the brink of profound transformations, the AI policy landscape has become a significant factor shaping global competitiveness and profoundly influencing our future. The notion that AI dominance is important for economic growth, strategic competitiveness, and military control has fueled AI strategy initiatives in many countries. AI has emerged as a pivotal social and economic policy priority and governments are intensifying their efforts in the field of AI, both with regulations and investments. While the strategic plans vary in focus and maturity, they commonly aim to boost research, improve data infrastructure, and address governance and ethical concerns. High-income countries tend to emphasize regulation and ethical guardrails, whereas emerging economies are now rapidly entering the field, often prioritizing foundational capacity-building. Meanwhile, global investment in AI is rising sharply, and divergent approaches, for instance between the West's cautious, ethics-driven models and the East's aggressive R&D focus, are shaping competitive dynamics. These insights are further discussed in the next few subsections.

#### *Development of national AI strategies and programs*

While governments continue to navigate the complex implications of AI, its transformative potential has spurred many to draft national strategies detailing priorities and resource allocation. These plans offer a glimpse into the current state of AI investments in Europe and the strategies employed by national governments to maximize their resources effectively.

*Denford et al (2023*) have examined six key elements in 24 national AI plans to understand how countries approach AI deployment. These elements include data and algorithmic management, AI governance, and R&D, educational, and public service reform capacity development. The

national approaches clearly differ from one another. However, Denford et al anticipate that over time WEIRD (Western, Educated, Industrialized, Rich, and Democratic) countries will converge on what is most important, and these insights will be reflected in their national plans. The release of national strategic plans has also been accompanied worldwide by substantial investments by governments in building and advancing their AI capabilities. For instance, France has committed 109 billion Euro, Canada has pledged 2.4 billion Euro, China has launched a $47.5 billion semiconductor fund, India has pledged $1.25 billion, and Saudi Arabia's project Transcendence represents a $100 billion initiative (*Maslej et al, 2025*).

Additionally, the release of national strategic plans has also been accompanied by concrete policies aimed at developing and attracting relevant talent and technology; many countries are turning to their education systems to develop world-class AI capabilities, enabling them to navigate and thrive in the era of the fourth industrial revolution.

***AI strategies are on the rise, particularly in low- and middle-income countries***

Oxford Insights evaluated 188 governments globally to assess their readiness to integrate AI into public services. Developing an AI strategy is the first step. In 2024, twelve new AI strategies were published or announced, tripling the number from 2023. Over half originate from lower-middle-income and low-income countries, including Sub-Saharan Africa, Latin America, South and Central Asia, and the Caribbean. This growth among historically lagging economies signifies a commitment to establishing foundational governance frameworks for AI readiness. These findings highlight AI's role as a powerful catalyst for national development (*Oxford Insights, 2024*).

### *Regulation and Legislation, Ethics and AI government*

National AI strategies, in addition to promoting the adoption of AI, also address policy concerns raised by AI applications. These concerns encompass privacy, safety and accountability, societal acceptance, algorithmic bias, transparency and explainability, and more. Policy makers have responded in diverse ways to these regulatory challenges: from adopting a "wait and see" approach to conducting "test and learn" experiments and even banning some specific digitally enabled business models (*Attrey, 2020*).

The adoption of AI has necessitated the creation of additional and domain-specific laws and regulations. For instance, the number of American federal AI regulations has doubled since 2023, with 59 introduced in 2024. Globally, AI mentions in legislative proceedings have increased by over 21% in 75 countries since 2023, a ninefold increase since 2016. Europe has a leading role in this. When worldwide AI mentions within legislative proceedings are aggregated from 2016 to 2024, Spain is first, followed by the United Kingdom and Ireland. In 2023 and 2024, countries worldwide also established international AI safety institutes, with the US and UK leading the way, but new institutes have also been pledged in by France, Italy, Germany, Australia, Japan, Singapore, South Korea, Canada, and the EU (*Masley et al., 2025*).

The American Brookings Institution identified five most desired outcomes in the AI strategies of 34 countries: AI research, AI data, algorithmic ethics, AI governance, and the use of AI in public services. AI research and data access were the most widely desired outcomes; these are two necessary preconditions for achieving the other outcomes. Democratic countries expressed greater concern for the ethics and governance, frequently addressing algorithmic ethics and AI governance challenges, while more authoritarian countries often lagged behind. However, among these democratic countries, those with less mature technology environments appeared to prioritized ethics and governance more frequently compared to those with a more advanced

technical infrastructure. This indicates that merely developing AI capabilities and systems is insufficient. Human-centric AI enabled by ethical and governance considerations is also essential. Public trust and the belief that the AI technology serves humans rather than the other way around are crucial for the long-term deployment of AI (*Fatima et al, 2021*).

The HAI report of Standford University found a rise in global AI optimism despite persistent regional divides. In countries like China, Indonesia, and Thailand, a substantial majority (77-83%) believes AI products and services are more beneficial than harmful. In contrast, optimism remains significant lower in, for example, the Netherlands, Canada, and the USA (36-40%). However, optimism has increased significantly with 4-10% in several previously skeptical countries since 2022, including Germany, France, the UK, Canada, and the USA (*Maslej et al, 2025*).

### *Divergent approaches*

*Denford et al (2023)* noted significant differences in AI development plans between the West and the East. The East prioritizes R&D, disregarding traditional technology management guardrails like data governance and management. In contrast, the West mainly focuses on establishing these guardrails and allocates less effort to building AI infrastructure. This “all-gas, no brakes” approach by the East will enhance its dominance in AI. Appropriate guardrails in AI development are important. The prudent strategy is to establish them while simultaneously developing AI. Otherwise, the West will fall behind, resulting in comprehensive guardrails without tangible value to safeguard (*Maslej et al, 2025*).

### *The USA leads in AI readiness, its advantage rests heavily on technology sector*

As previously mentioned, Oxford Insights assesses government readiness to integrate AI into public services. In their ‘*Government AI Readiness Index*’ they evaluated 188 countries and 40 indicators divided into three main pillars: government, technology, and data & infrastructure. Singapore leads in both government and data & infrastructure. When we examine the size and development of a country’s tech market, as well as its innovation capacity, the USA outperforms the global average. Its leadership is primarily attributed to a dominant position in the technology sector, having a substantially larger and more mature market compared to other countries. The USA hosts numerous global tech giants and has a well-established network of suppliers providing AI tools for public purposes. This ecosystem is exceptionally well-funded with unparalleled access to venture capital (*Oxford Insights, 2024*).

Stanford University Human-Centered Artificial Intelligence’ ‘*AI Vibrancy Index’* ranks 36 countries based on 42 indicators that, for example, evaluate research & development in terms of academic publications and citations, intellectual property generation, investments and start-ups,

talent and skills. Once again, the USA leads, with China in second place. The report also offers valuable insights into patenting. AI patenting is on the rise. Figure 1 illustrates the global growth in granted AI patents over the period from 2010 to 2023. During this period, the number of AI patents has increased substantially, from 3,833 in 2010 to 122,511 in 2023. The gap in AI patent grants between East Asia and the Pacific and North America has widened steadily. Today, East Asia and the Pacific account for most granted AI patents globally, with North America being the second-largest contributor (Figure 2; *Masley et al, 2025; Stanford University, n.d.*).

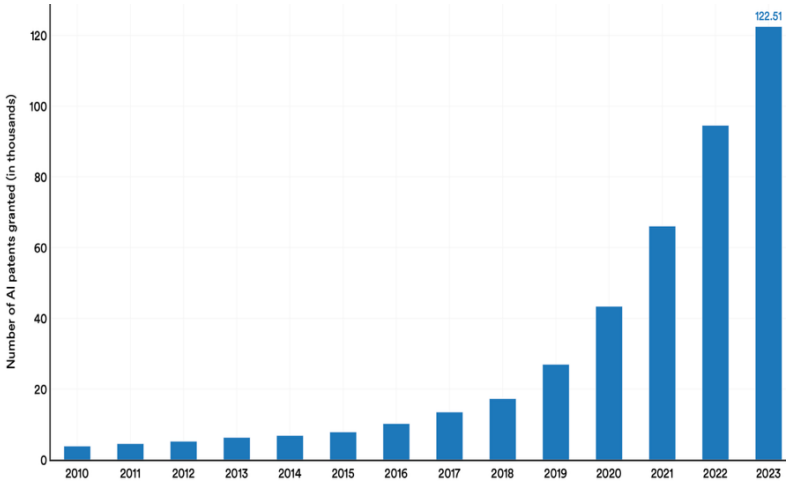



*FIGURE 1: Number of AI patents granted worldwide in the period 2010-2023. Source: AI Index 2025 (Maslej et al, 2025).*

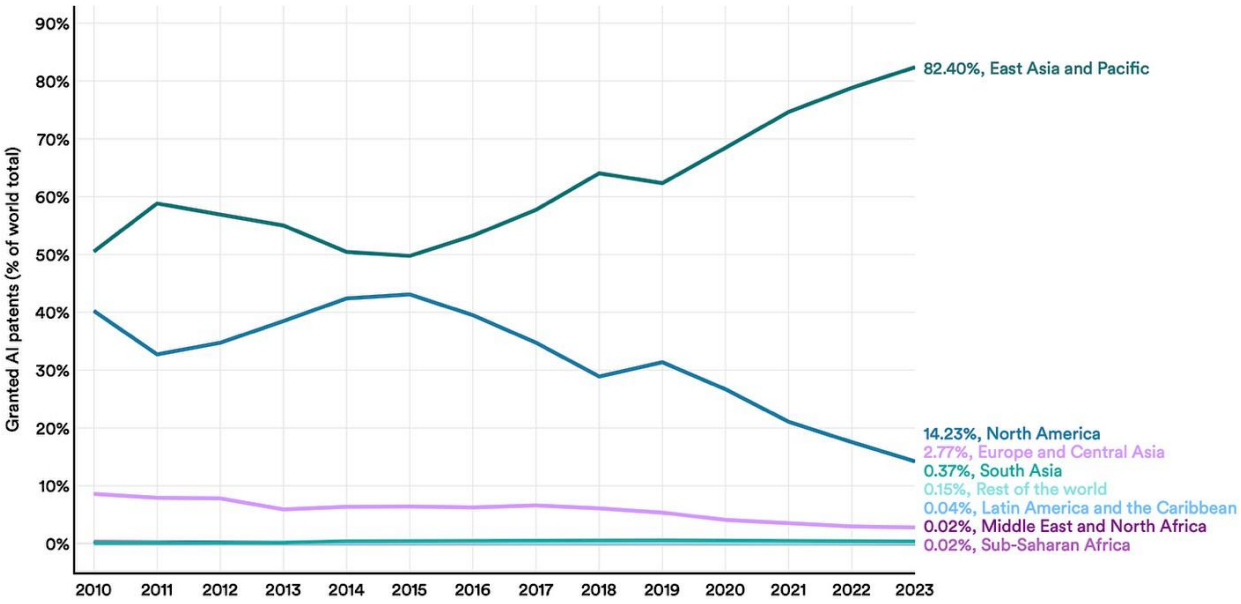



*FIGURE 2: Granted AI patents by region in the period 2010-2023 (expressed in % of the world total). Source: AI Index 2025 (Maslej et al, 2025).*

The '*Global AI Index of Tortois'* benchmark evaluates 83 countries based on their investment, innovation, and implementation of AI. The ranking is based on 122 indicators categorized into three pillars: implementation, innovation, and investment. The USA and China maintained their historical positions as the first and second-place leaders in all three pillars, while the UK secures the third spot. France has experienced a significant surge in its ranking, climbing to the sixth

position due to the emergence of a robust generative AI ecosystem within the country. Germany has steadily improved its ranking since 2021, while Israel and Canada have continued to drop (Figure 3; *Tortois, 2025*).

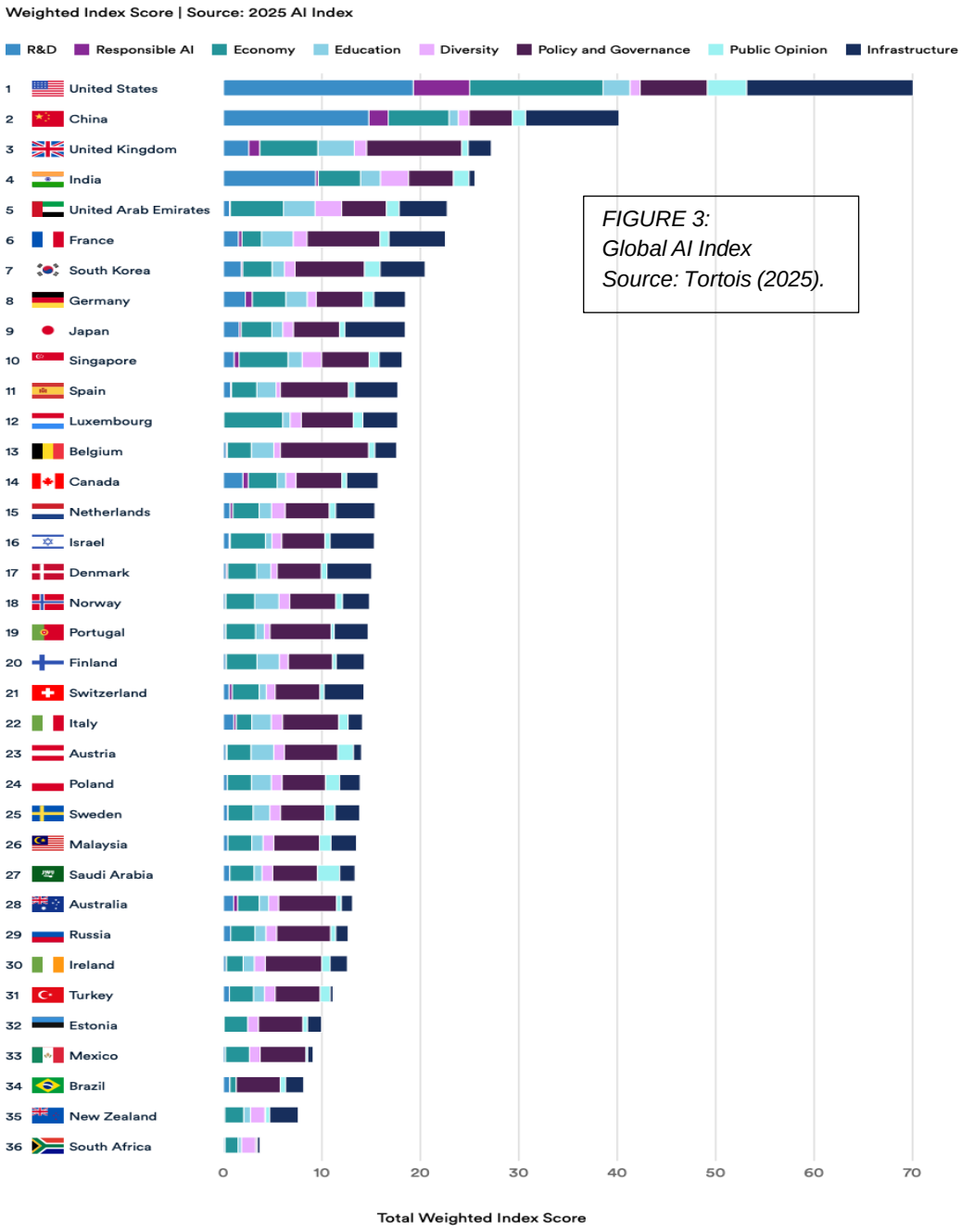



*FIGURE 3:*
*Global AI Index*
*Source: Tortois (2025).*

### 4.4.2 EUROPE

Against this global backdrop, it is essential to examine how Europe is positioning itself in the AI landscape. Europe has made significant strides in shaping a distinctive approach rooted in trust, ethics, and human-centric values. While many Member States have developed and updated national AI strategies, disparities remain in implementation speed, investment levels, and technological capacity, particularly between Western and Eastern Europe. Europe performs strongly in international benchmarks like the Government AI Readiness Index, reflecting its robust governance structures, advanced data infrastructure, and commitment to innovation. Yet, staying competitive in a fast-evolving global landscape will require sustained investment in AI research, digital infrastructure, and skills development, as well as enhanced coordination across governments, stakeholders, and international partners. Continued international collaboration and effective implementation of initiatives like the EU AI Act are crucial to ensuring that Europe not only keeps pace but also helps shape a responsible global AI future, as will be outlined in the sections below.

The European Union's approach to AI is predicated on excellence and trust. It aims to stimulate research and industrial capacity while simultaneously ensuring safety and fundamental rights. The European AI ecosystem is characterized by its complex, interconnected, and highly collaborative nature. The challenge lies in achieving a balance between innovation and responsible, human-centric AI deployment, while ensuring transparency and accountability. Policies such as the Regulatory Framework on AI (the 'EU AI Act') propose regulatory frameworks to govern AI applications, particularly those deemed high-risk (*European Commission, 2024)*.

The European Commissions' website AI Watch (*European Commission, n.d. 2*) contains chapters with detailed country information about policies identified in their national AI strategies. Unfortunately, the latest update was in 2021. Another, also already somewhat older source is the 2020 Global AI Strategy Landscape by *HolonIQ (2020)*, which mapped out 50 national artificial intelligence strategies from 2019 to 2020, representing 90% of the global GDP. The OECD (Organisation for Economic Co-operation and Development, *OECD.AI, 2025*) is also a useful knowledge hub for data, analysis, and best practices in public policy. On its website is a section providing a repository of over 1,000 AI policy initiatives from many countries. This database houses national AI strategies and AI-related policy initiatives.

The national AI strategies have evolved at different rates. The United Kingdom and Finland were among the pioneers, establishing national AI strategies and allocating budgets around 2017. France, Germany, the Netherlands and Sweden followed in 2018 and 2019. In 2020, several other countries joined the race, including Bulgaria, Hungary, Poland, and Spain. Some European countries, such as Croatia, still do not have an official AI strategy (see Chapter 5). National AI strategies typically set the objectives, followed by action-plans to implement the strategy. In later years, several countries have updated their national AI strategies and started to track their progress (*Galindo, 2021; OECD, 2021*). Strategic AI visions of the European Member States are still being developed and updated. For example, in 2024 Italy updated its AI Strategy and the Netherlands released a national vision for Generative AI.

#### Government AI Readiness

Europe remains a strong performer in the '*Government AI Readiness Index*' of Oxford Insights. North America leads the Index (with an overall score of 82,60), followed by Western Europe (average score of 69,56), East Asia (average score of 57,95), and Eastern Europe (average score of 57,88) in the subsequent positions. Within Western Europe, France leads the regional ranking, narrowly surpassing the United Kingdom. The region dominates the global top 10, with the Netherlands, Germany, and Finland joining France and the UK, giving Western Europe the largest regional presence in the upper tier (Figure 4). According to the report, '*the continued presence of multiple European member states in the global top 10 highlights the region's leadership in AI readiness'*. Western Europe surpasses the global average across all three pillars Government, Technology sector, and Data & Infrastructure, and excels particularly in the Data & Infrastructure pillar. This robust performance is attributed to its advanced data infrastructure, mature governance frameworks, and strong foundations for AI innovation. Estonia is the sole Eastern European country to make it into the global top 25. The Eastern European region also surpasses the global average across all three pillars, with its strongest performance, similar to Western Europe, in the Data & Infrastructure pillar. However, the Technology Sector remains a challenge, underscoring the necessity of increased investment in technological capacity and innovation to fully realize the region's potential (*Oxford Insights, 2024*).

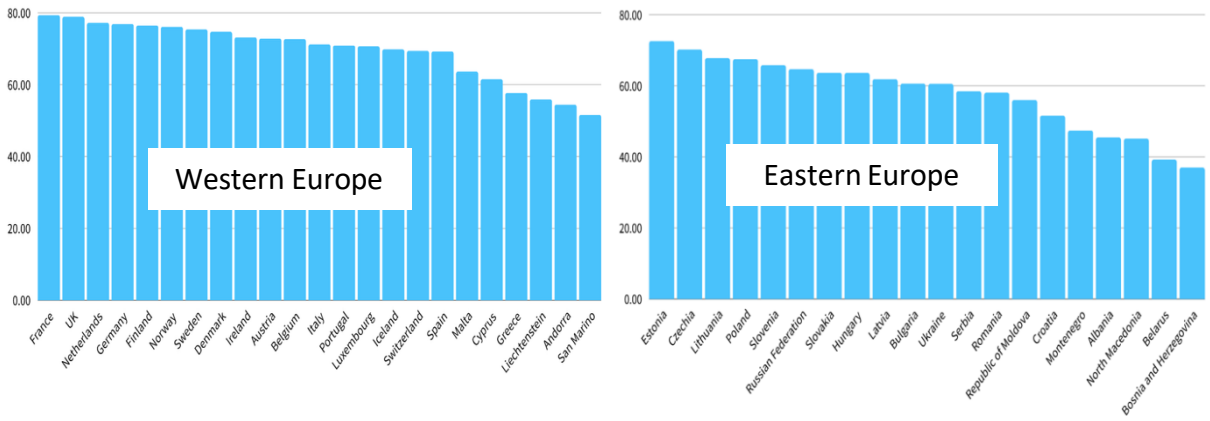



*FIGURE 4: Oxford's Government AI Readiness Index overall score of Western and Eastern Europe coutries. Source: Oxford Insights (2024)*

## International co-operation on AI

AI is a key priority for Horizon Europe, the European Union's framework program for research and innovation. Numerous member states actively participate in Horizon Europe's projects. Additionally, numerous intergovernmental organizations with complementary mandates and membership are engaged in AI initiatives and projects. EU member states also actively participate in these intergovernmental organizations and Public-Private-Partnership networks, including the Big Data Value Association (BVDA), euRobotics, Adra (AI-Data-Robotics Association), Confederation of Laboratories for AI Research in Europe (CAIRNE), and the European Laboratory for Learning and Intelligent Systems (ELLIS).

Global governance and international collaboration are important for responsible and effective adoption of AI. Shared frameworks, international standards, and regional cooperation provide governments with resources, best practices, and a common understanding of AI's potential and risks. In 2024, the European Parliament passed the landmark EU AI Act, establishing a

framework to ensure that AI upholds human rights, democracy, and the rule of law. The AI Act establishes rules governing the development of AI applications and introduces comprehensive provisions for transparency and reporting obligations, risk-based regulations, and bans on certain applications such as human manipulation and biometric categorization that uses "sensitive characteristics." This demonstrates a growing commitment to international cooperation in addressing AI risks. The European Union also established its AI Office to oversee the implementation of its flagship AI Act. Member States are streamlining their AI governance and Spain has taken the lead by creating the EU's first AI Agency, the Spanish Agency for the Supervision of AI (AESIA). In a similar vein, France has appointed its first-ever Secretary of State for AI and Digitalization (*Maslej et al, 2025; Oxford Insights, 2024*).

## AI policy design and implementation

The OECD published an AI policy cycle: Policy design, Policy implementation, Policy intelligence, and International and multi-stakeholders' cooperation on AI. Because these are the fundamental components of national policymaking, this format is adopted in this paper, with the primary focus on the first two points (*OECD, 2021; Galindo, 2021*).

- ***Stakeholder involvement***
  To gather input on their national AI policies at the various stages of design and implementation, many governments involved a diverse group of stakeholders, including research organizations, companies, citizens, civil society organizations. Such an approach guarantees public support and enhanced social acceptance, but it can also result in delays in the process. While countries like Finland, for example, prioritized becoming an AI leader and made the necessary resources available to achieve this goal, countries as the Netherlands focused on reaching consensus among stakeholders (the Dutch consensus-building 'polder-model') and defining, discussing and refining policy approaches between ministries and created a rather complicated route to release funds through existing instruments to implement the strategy (*Lazo et al, 2023; Ailistyo et al, 2023*).

- ***Goals***
  European Member States' AI policies differ in objectives. Some countries focus more on scientific excellence, innovation in AI, and leadership. Others' focus can be mainly on the use of AI and innovation with AI. Finland and Germany are examples of countries that were actively working to develop further their leading AI position. Finland published its first AI strategy, titled "Finland's Age of Artificial Intelligence," in 2017. This strategy already outlined policy actions aimed at making Finland a frontrunner in AI. Germany published its AI strategy in 2018 and aimed to establish itself as a leading center for AI. Their clear goal was to make "AI made in Germany" a strong export and a globally recognized quality mark (*Ministry of Economic Affairs and Employment of Finland, n.d.; OECD, 2021; UNCSTAT, 2017*).

- ***Government***
  Effective implementation of national AI initiatives requires coordination across government. The OECD (*Galindo, 2021; OECD, 2021*) highlighted the following models employed by governments to ensure policy coherence and successful implementation:
  (1) Assigning oversight of the development and implementation to an existing ministry or agency.
  (2) Creating a new governmental or co-ordination national body.
  (3) Establishing multi-stakeholder AI expert advisory groups, tasked to identify opportunities, risks and challenges.

(4) Oversight and advisory bodies for AI and ethics, because it is essential to understand the public's sentiments regarding AI to increase its societal acceptance and adoption.

- ***Investments in AI research & development***
  As AI continues to revolutionize important societal sectors, countries are actively supporting the establishment of national multi-disciplinary AI research institutes (e.g. France and Germany) and are funding AI research, development, and innovation projects. Public budgets for AI research and development differ across countries, and there are no reliable, comparable estimates of public investments available. Moreover, when budget figures are available, they often fail to include the substantial AI research & development investments by national defense bodies. Funding instruments often prioritize mission-driven investments in specific economic sectors and procure AI systems for the public sector (see Adra-e Deliverable 4.7).

- ***Digital infrastructure and AI innovation eco-systems***
  Developing and using AI necessitates access to AI technologies, data, and infrastructure. Many countries have developed policies to facilitate data accessibility, including data spaces. In addition to access to data and algorithms, computing capacity plays a pivotal role. Therefore, policies increasingly prioritize investments in digital AI infrastructure, such as high-performance computing and AI Factories to enhance AI adoption and usage.

  In 2024, the UK invested £300 million in the first phase of its new AI Research Resource (AIRR), a cluster of advanced computers for AI research & development. In the same year, France, Poland and Germany formed an alliance to coordinate their national AI investment strategies with EU policies. Also the Nordic countries initiated an ambitious project to establish a cross-border collaborative AI research and innovation center equipped with advanced digital infrastructure (*NordForsk, 2024; Oxford Insights, 2024; UKRI, 2023*).

  Access to sandboxes and quasi-real-world AI Test and Experimentation Facilities, such as the European TEFs, enables the identification of potential technical flaws and governance challenges. European Digital Innovation Hubs (EDIHs) serve as one-stop shops to support SMEs' digitalization. They provide Test-before-Invest facilities, and access to funding, networking and training services. The European Commission encourages cooperation between EDIHs from different regions. To foster domestic innovation, the EU also has recently invested €1.5 billion through the European High Performance Computing Joint Undertaking to establish seven European AI factories (*European Commission, n.d. 12*).

  Several countries have established joint AI research networks and collaborative platforms, including AI hubs, AI labs, and AI accelerator programs, to facilitate cooperation between industry, academia, and public research institutes. These centers complement the above-mentioned application hubs that provide support to SMEs in adopting AI technologies. Connected to these AI research and innovation ecosystems are various activities that support SMEs, encouraging them to innovate and adopt AI.

  Multiple European countries have established joint AI research networks and collaborative platforms, such as AI-labs, AI-hubs, AI-accelerator programs, to facilitate cooperation between knowledge institutes and the industry. These centers complement the above-

mentioned application hubs that provide support to SMEs in their adoption of AI technologies.

April 2025, the European Commission presented its 'AI continent action plan'. The plan outlines how to unlock the potential of European researchers and industries. Building on the launch of the InvestAI initiative, which will mobilize 200 billion Euro for investment in AI in the EU, the AI Continent Action Plan aims to enhance AI capabilities across five areas (*European Commission, 2025, European Commission, n.d. 1*).

(1) Building a large-scale AI computing infrastructure.
- Setting up at least 13 AI Factories across Europe to support startups, industry, and researchers to develop cutting-edge AI models and applications.
- Establishing up to five AI GigaFactories, large-scale facilities with massive computing power and data centers to train complex AI models. These high-capacity AI infrastructure hubs build on the existing AI Factories initiative, but with significantly greater compute power, integrated data resources, and automation. This requires both public and private investment. The InvestAI facility aims to mobilize 20 billion Euro to drive private investment in the GigaFactories.
- The Cloud and AI Development Act will stimulate private investment in cloud and data centers.

(2) Increasing access to high-quality data.
Among others via a Data Union Strategy and Data labs within AI factories.

(3) Promoting AI in strategic sectors.
AI factories and European Digital Innovation Hubs (EDIHs) will be used to implement the strategy.

(4) Strengthening AI skills and talents.

(5) Simplifying the implementation of the AI act.

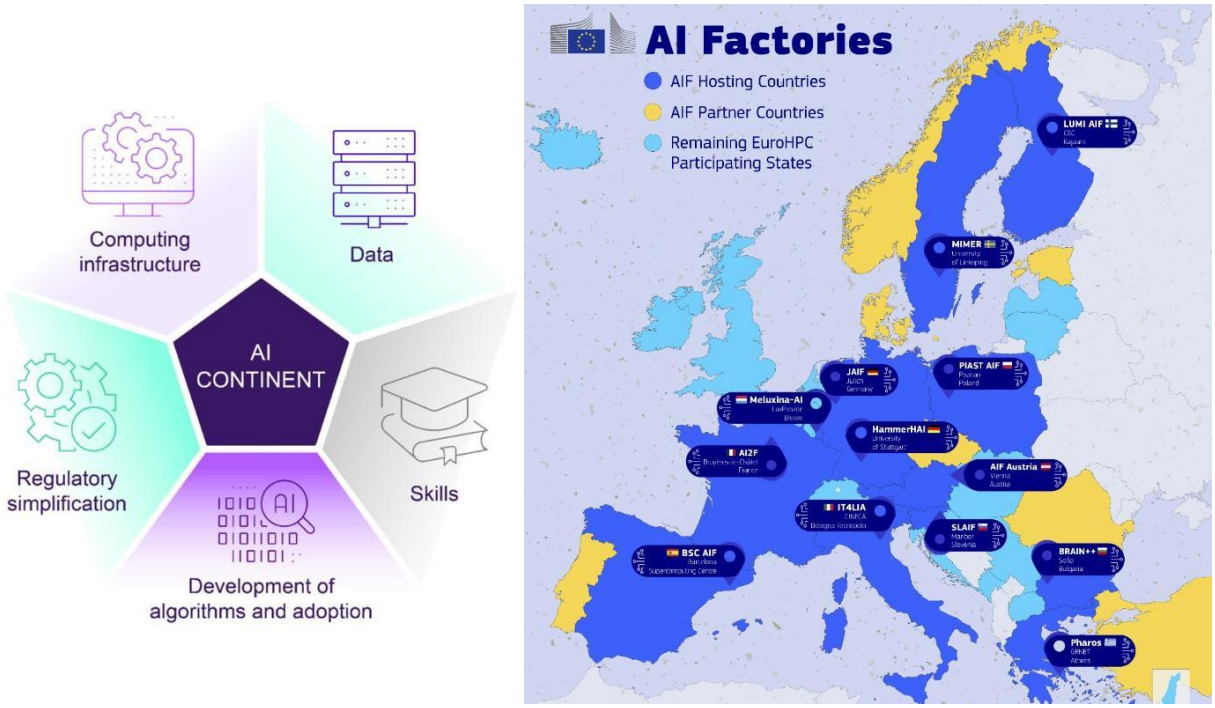



*FIGURE 5: The five main focus areas of the 'AI Continent Plan' of the European Commission, and the distribution of the AI Factories across Europe. Source: European Commission (2025).*

# 5. REGIONAL: ODENSE ROBOTICS IN DENMARK

Authors: Iddo Bante, Anne Bergen
Adra-e WP4 T4.4 contribution
Date: 2025-06-01

*Denmark, especially the small city of Odense, has build-up a vibrant thriving robotics and automation eco-system that's caught the attention of the world. In a relatively short amount of time, the country and its Odense region have become one of the main players worldwide. How did a small country with just six million people achieve this? What makes this ecosystem so special? How is it organized? What are the strengths and weaknesses of the Danish robotics cluster? How do companies and institutions making up the cluster contribute to its success?*

## 5.1 THE ODENSE REGION

*Fifteen years ago, Denmark, a small country with approximately 6 million inhabitants, was barely known in the global, innovative robotics market. And the Danish city of Odense was perhaps best known for being the birthplace of the fairy tale writer Hans Christian Andersen. But in a relatively short time, the Danish robotics, automation and drone cluster became an important player globally. The Danish city of Odense played and pivotal role in this development. This chapter will explore the key changes and factors that fueled this remarkable transformation.*

### 5.1.1 Odense turned industry decline into an opportunity

Today, Odense is the third largest city in Denmark and the largest city on the island of Funen in South Denmark. As of 1 January 2024, the Odense Municipality had a population of approx. 210.000. How did a relatively small country achieve such a remarkable accomplishment and ascend to become a world leader in robotics?

Odense's robotics cluster has deep roots in the city's steel working and shipbuilding industry. The first yard of the Odense Steel Shipyard company opened in 1919. It was known for building the largest container ships in the world for its parent company, world's largest shipping company the A.P. Møller - Mærsk Group. Since the early 1980s, ship manufacturing shifted more and more to Asia due to Asia's greater competitiveness, leading to the decline of European shipyards. In 2009 the Odense Steel Shipyard, Denmark's largest shipbuilding facility, announced its closure and the last ship was delivered in 2012.

Fortunately, amid this challenging period, a significant development had already taken place. In the early 1980s, the Mærsk Odense Steel Shipyard who found itself in intense competition with Asian shipyards, particularly those in Japan using welding robots had realized the necessity of automation in the shipbuilding industry to improve production efficiency. Recognizing the potential of robotic assistance in welding, Mærsk started a collaboration with a Japanese welding robot manufacturer. Since the programming of the welding robots presented intricate challenges, Mærsk made the strategic decision to invest in research and initiated robotics research collaborations with Aachen University (Germany) and Osaka University (Japan). Odense University, which would later become the University of Southern Denmark, was deemed less pertinent at that juncture. Independently of this, in 1988, Odense University organized meetings between local entrepreneurs and researchers, which led to several initiatives. One of these initiatives involved a project with the Odense shipyard to simulate the movement of a welding robot. This project not only catalyzed further collaboration but also gave rise to the Autonomous Multiple Robot Operation in Structured Environments (AMROSE) project in 1990. In 1996, the company AMROSE was established as a joint venture between Mærsk and the university to commercialize the acquired knowledge. In 1997, approximately 200 individuals were involved in R&D projects at the Odense Steel Shipyard, with 50 from the shipyard and 150 from outside (*Ingstrup, 2024*).

To ensure research continuity, in 1997 the university and shipyard established the Mærsk McKinney Møller Institute for Production Technology. The institute was founded through a donation from Mærsk McKinney Møller - the largest private donation ever made to a Danish

university at that time. The institute laid the foundations for Danish research in robotics, drew experts to Funen, and created the knowledge and expertise that is still firmly rooted in the area.

However, this progress was neither spontaneous nor without challenges. In the early 2000s, a global recession caused a sharp decline in orders, prompting many European companies to relocate production to low-wage countries. In response, A.P. Møller-Mærsk decided to discontinue robotics research at Odense Steel Shipyard. This posed a significant challenge for Odense, as the research activities were primarily aimed at meeting the shipyard's specific needs. The Municipality of Odense, the County of Funen, and local companies joined forces, and together with other stakeholders they successfully secured external R&D funding.

Over the years, A.P. Møller and the A.P. Møller & Chastine Mc-Kinney Møller Foundation have donated hundreds of millions to facilitate robotics research at the Mærsk McKinney Møller Institute. Many individuals who later played pivotal roles in the development of the Danish robotics and automation and drone cluster were trained and educated under the auspices of this institute (*Ingstrup, 2024; Steno & Grouleff, 2020; Invest in Odense, 2023a; Techsavvy, 2022*). What began as a response to industrial decline evolved into a globally recognized robotics ecosystem, transforming Odense from a traditional shipbuilding city into a world-leading hub for robotics innovation.

### 5.1.2 Talents attract talents

In 2006, the Danish Technological Institute made the strategic decision to relocate its robotics department to Odense. This relocation enabled the institute to integrate into the emerging vibrant robotics ecosystem surrounding the Mærsk McKinney Møller Institute.

This fertile environment in Odense gave rise to numerous successful companies, including two early pioneers: Universal Robots and Mobile Industrial Robots.

- Universal Robots (UR), founded in 2005 by three young researchers from the University of Southern Denmark, was inspired by the huge potential of robotics but frustrated by the limitations of existing industrial robots. They aimed to revolutionize the field by making robot technology accessible to SMEs by launching a lightweight cobot that was easier to install and program than traditional industrial robots. This innovative idea led to the establishment of UR (*Universal Robots, n.d.*).
- Mobile Industrial Robots (MiR) was founded in 2013 with the idea of optimizing logistics in the global industry. Today, MiR has 450 employees and more than 200 distributors in 60 countries (*Mobile Industrial Robots, n.d.*).

Both companies were acquired by the American company Teradyne, which significantly elevated Odense's global profile. The sale of UR in 2015 underscored Odense's strategic acumen; the sale of MiR in 2018 'demonstrated that Denmark, with Odense as its center, had reached the top of the global robotics league' (*RobotReport, 2024c*).

Teradyne's management decided that the two acquired firms should maintain their focus on the Odense robotics ecosystem and allocated resources to establish new infrastructure facilities. These investments have significantly strengthened the region's position as a global hub for robotics innovation. As a result, new innovative entrepreneurs, both domestic and international, entered the Odense ecosystem. This led to the emergence of collaborative robot firms in

various industries, such as construction, agriculture, production, offshore, and healthcare. This shift in focus from industrial robots for shipbuilding to collaborative robots substantially enhanced the cluster's reputation. It also attracted renowned international robot manufacturers, talent, and investment to Odense (*Ingstrup, 2024*).

Currently, Odense boasts a thriving robotics eco-system, employing approximately 3,600 individuals across over 160 companies and organizations. This remarkable feat places Odense among the European cities with the highest concentration of people per capita employed in the robotics sector.

### 5.1.3 Reinventing Odense

The previous developments clearly show that Odense's emergence as a global leader in robotics is no coincidence. This success is rooted in a strong historical foundation, built over decades through sustained collaboration between companies, the University of Odense, and local and regional government actors. Together, their long-term commitment and coordinated efforts have shaped a thriving and resilient robotics ecosystem

Many people from that time have been key to the success. It was a perfect blend of technology, business development, and entrepreneurship. Odense's thriving robotics industry is all thanks to its awesome robotics ecosystem, where everyone works together and supports each other. The success lies in an interdisciplinary approach, mutual trust, a collaborative and entrepreneurial mindset, demanding customers, creativity and a pro-robot population. The administration of the city of Odense also played and pivotal role in this transformation and the development of the robotics and automation eco-system (*Steno & Grouleff, 2020; RobotReport 2024d*).

## 5.2 THE NATIONAL CLUSTER ODENSE ROBOTICS

### 5.2.1 Innovation clusters

Clusters play a pivotal role in the incubation, growth, funding, and nurturing of roboticists and their enterprises. They involve many different stakeholders: companies that use and develop robots, engineers and entrepreneurs seeking inspiration from successful start-ups and scale-ups, students seeking inspiring studies and job opportunities, educators interested in the practical applications of their research, training, and students' work, investors interested in participating in robotics companies with growth potential, governments that want more jobs and future-proof tech businesses in their region, and all kind of supporting organization providing guidance on navigating regulatory frameworks, business modelling, international trading and cooperation, etc. By bringing these diverse actors together in close proximity, clusters create a dynamic environment where ideas, talent, and resources can rapidly circulate and converge. Such clusters are organized to foster innovation, facilitate knowledge sharing, support startups and scale-ups, provide access to funding, offer coaching, and assist businesses in achieving success (*RobotReport, 2016*).

Clusters don't emerge by accident; they can be planned. They need a vibrant community, where all stakeholders are willing to share their knowledge and actively participate, and a certain level of altruism. They also need nearby universities with strong technical research and educational systems to foster the development of new talent and innovative research solutions to local challenges. Furthermore, clusters necessitate organizational structure.

Robotics clusters worldwide are working hard to meet the needs of their communities. The Danish robotics cluster has achieved remarkable success due to their comprehensive organizational structure. It is well organized at every level and ensures the provision of the right services and the presence of business-savvy, humble, and cooperative individuals.

### 5.2.2 Odense Robotics: the national robotics, automation and drone cluster

Over time, a great deal of knowledge of automation has been accumulated in Odense. While the robotics industry was rapidly growing around Odense, since the turn of the millennium noteworthy developments also took place in several other regions, e.g. around the Technical University of Denmark in Copenhagen and the University of Aalborg. Nowadays, Denmark is home to more than 600 robot-automation-drone companies, employing a total of 19,500 people - 14,900 in Denmark and 4,600 abroad. The industry has demonstrated stable growth over recent years and is internationally recognized as a global frontrunner. Odense is ranked as a 'strong innovator' in the European Regional Innovation Scoreboard 2023 by the European Commission (*European Commission, n.d. 3*). In 2023, the industry generated a turnover of 4.6 billion Euro, of which 2.4 billion came from exports. The USA and Germany are the main export markets, followed by the UK and Norway (Figure 1; *Odense Robotics, 2025; RobotReport 2024d*).

To foster growth, create critical mass, build trust, mentor startups, support scale-ups, and engage in numerous other vital activities, a structured approach was necessary. Odense

Robotics, Denmark's national robotics, automation and drone cluster, played a pivotal role in this endeavor. Odense Robotics comprises over 350 members across Denmark and is headquartered in Odense. The cluster is designed with a nationwide setup, featuring regional hubs strategically located across the country in Aalborg, Aarhus, Copenhagen and Sonderborg. The Odense Robotics cluster is characterized as firm-led with public support (*Ingstrup, 2024*).

Their primary objective is to help Danish robotics, automation, and drone companies in developing innovative technologies and products and in growing their businesses. They're like the Swiss Army Knife of this Danish robotics sector. They help companies come up with cutting-edge products and technology, build a solid foundation for growth, gain industry insights, build strong relationships, and increase their visibility. Partnerships and knowledge-sharing are considered essential for unlocking the full potential of Danish robotics. Next to joint projects, network events and collaborations between the members of the cluster, promotional activities and events also play a crucial role in its initiatives (*Odense Robotics, 2025*). Having a vision on your own is one thing, but bringing multiple people together with a shared vision is much more powerful. This is precisely what the Odense Robotics cluster has achieved in the field of robotics. Today, the cluster has attained a critical mass and is now neck and neck with the bigwigs in the robotics world across Europe, the US, and Asia.

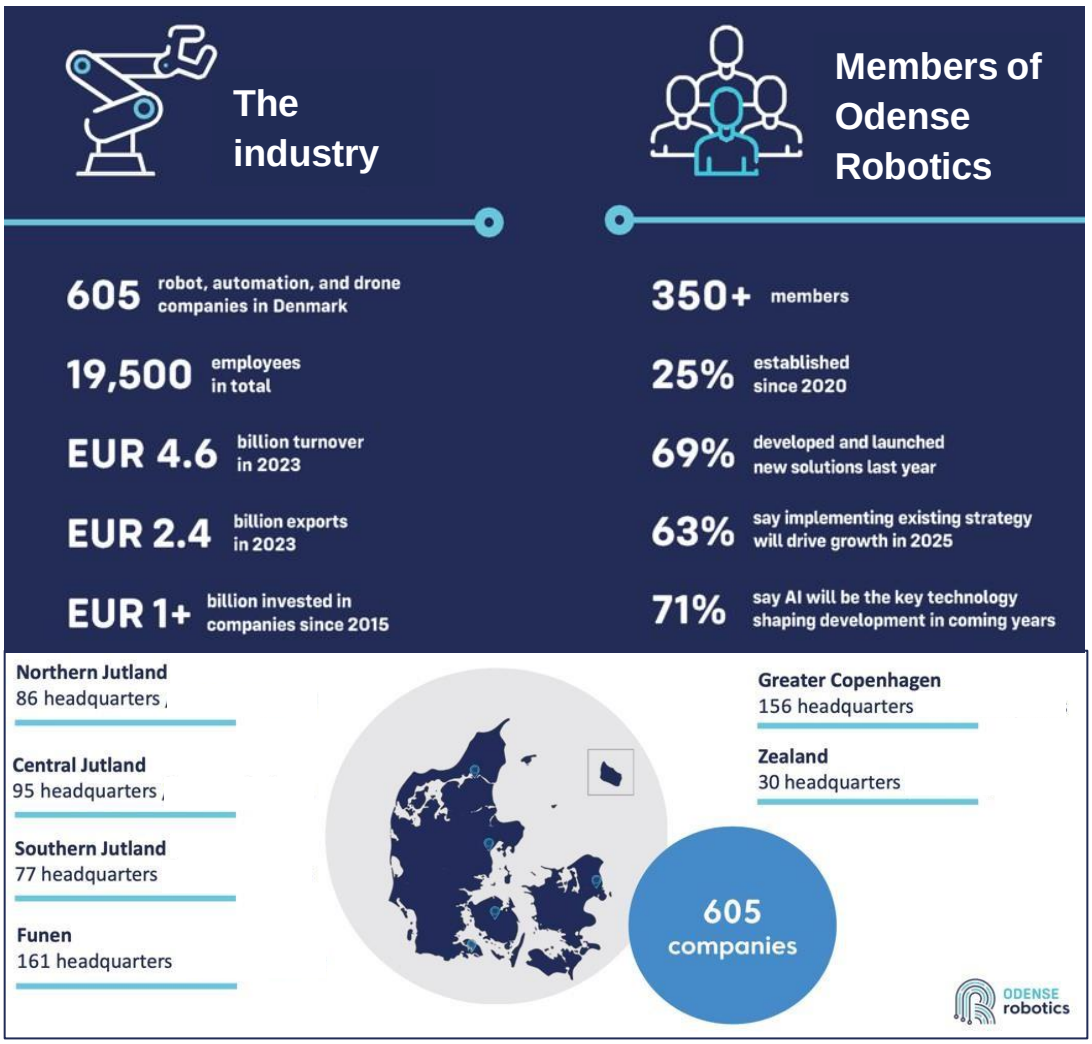



*FIGURE 1: Denmark's robot, automation, and drone industry in 2025*
*Source: Odense Robotics (2025)*

### 5.2.3 Danish way of working: The benefits of a small country

Denmark's small size further strengthens this dynamic by fostering a strong sense of community and a culture of personal connections. The Danish culture is founded on a profound level of trust among its diverse partners. There has been a common understanding that talent should not be actively recruited from other companies within the cluster.

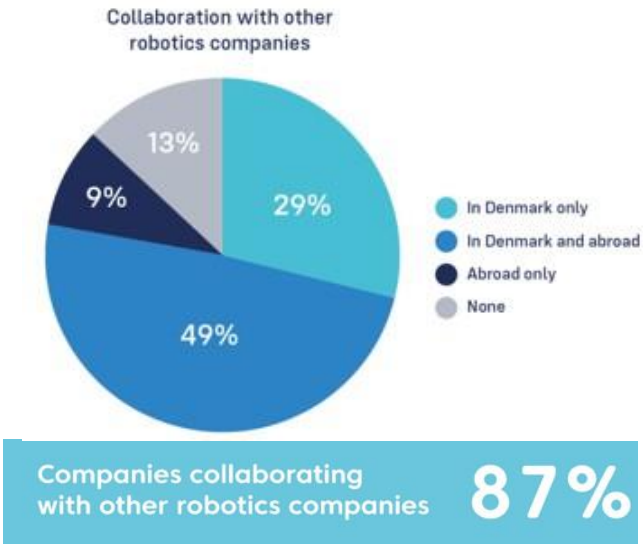



*FIGURE 2: Collaboration thrives in the Odense Robotics cluster and plays a key role in de industry's ability to innovate and commercialize new technologies Source: Odense Robotics (2025).*

Denmark is also known for its sharing culture, where knowledge flows easily through strong relationships and a willingness to work together (Figure 2). The Danish robotics cluster's growth and success can be attributed to its collaborative approach rather than competition. Companies have demonstrated a willingness to share knowledge, fostering a culture of cooperation. Big and small companies team up to create new products, drawing inspiration from the research community. The Universal Robots product ecosystem exemplifies this concept. The company manufactures robotic arms of various sizes, but independent companies within its ecosystem produce the components, kits, and solutions necessary for these robots to perform a wide range of industrial tasks.

Denmark doesn't have a single dominant industry where big companies are fierce competitors. (as shown in the next section). Most Danish robotics companies operate in global niches, making it easier for them to collaborate. It's not only about cooperation among companies but also about forging strong ties between businesses and academic institutions. Universities engage in knowledge exchange with businesses, facilitating the interaction of students and researchers with industry professionals. Companies and universities have open discussions about relevant education programs to ensure that they train the best and most qualified workforce. By sharing knowledge and experience, these entities contribute to their collective growth and development

Initially, the cluster was fortunate that most companies were not direct competitors. That has now changed somewhat, but another advantage of being a small country is that new businesses must aim globally if they want to reach a large market. Many successful Danish startups were 'born global.' Since the Danish market is small, it has become a part of Danish culture to

consider selling products in other countries from the start. This global mindset has been key to the cluster's resilience and its ability to thrive in the robotics landscape.

### 5.2.4 Industrial diversity of the cluster

Denmark doesn't have a single dominant industry and most Danish robotics companies operate in global niches. A significant advantage of the Danish robotics cluster lies in its independence from specific industries. Unlike specialized clusters that emerged from and support a particular industrial sector, such as the manufacturing or automotive industry, the Danish robotics cluster operates without being tied to any particular sector. The Danish robotics industry has developed from a strong research tradition, a wealth of ideas, and the ability/capability to continuously renew itself. This unique foundation equips them to provide adaptable, flexible, and comprehensive solutions to production companies across various industries.

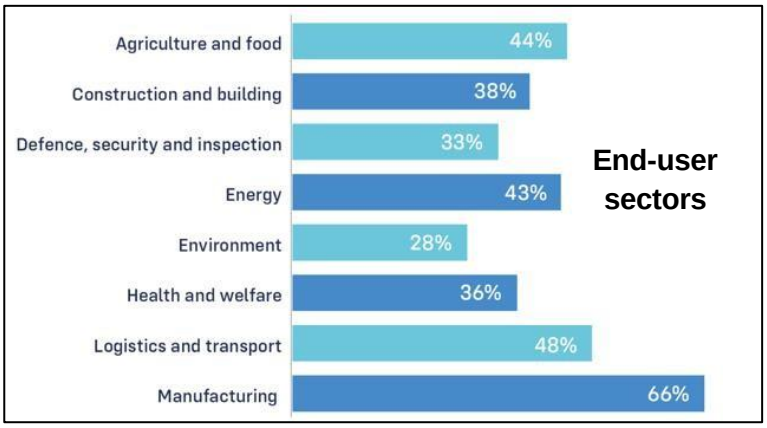



*FIGURE 3: Denmark's robotics, automation and drone cluster is providing automation solutions to many sectors, Source: Odense Robotics (2024a).*

Figure 3 shows that the members of Odense Robotics are not confined to industrial manufacturing. Although manufacturing is their most important end-user sector of interest, they also serve many other markets such as healthcare, agriculture, construction, logistics and security.

### 5.2.5 Strategic partnering

Building and maintaining international relationships is a smart move. These relationships are valuable assets that can lead to long-term success. Odense Robotics is taking Denmark's robotics industry to the world stage. They showcase Denmark's robotics solutions, companies, and ecosystem to decision-makers, end-users, and talent worldwide. Odense Robotics also stimulates international collaborations and strategic partnerships (*Odense Robotics, 2025*). Two recent examples are provided below.

In 2023, Denmark and the USA teamed up to build a 'robot bridge' across the Atlantic Ocean. This strategic partnership between the Pittsburgh Robotics Network and Odense Robotics aimed to boost business growth between the two sides of the Atlantic. This collaboration effectively consolidated ties between two prominent global robotics ecosystems, paving the way for mutual reinforcement of these ecosystems (*Invest in Odense, 2023b*).

In 2024, Odense Robotics and the National Robotics Program in Singapore joined forces to enhance robotics development and adoption. Singapore is a gateway to Southeast Asia and has a thriving and growing robotics ecosystem with over 250 companies and several prominent

robotics academic institutions. Singapore is the second most automated country in the world, with a high density of industrial robots in manufacturing. Robots are anticipated to be used more-and-more in various other sectors like aviation and shipping, logistics, facility management, and healthcare. This opens lots of growth opportunities for Danish robotics companies (*Odense Robotics, 2024b*).

### 5.2.6 Talent

As previously mentioned, Danish culture is deeply rooted in trust, and they are known for their sharing culture where knowledge flows easily. The Danish robotics clusters proved to be a powerful magnet, fostering fertile ground for talent development, attracting talented individuals, venture capital, and companies. Although there is a common understanding that talent should not be actively recruited from other cluster members, these open-minded organizations provide carreer opportunities for individuals and accelerate their professional development, gain practical experience, and continuously update their skills. Talented individuals contribute to the performance of the entire cluster because they accumulate experience as they move around between cluster members. Individual companies benefit from the effects of “pollination” due to this mobility. Employee mobility facilitates mutual enrichment and exchange between companies, contributing to the overall innovation process, although firms within the clusters also remain in competition with each other (*Chabault et al, 2012*).

Talent is a strategic asset. To maintain Danish developments as among the world’s most cutting-edge and sought-after technologies and services, employees are needed with the right competencies. Education programs and research conducted at the Danish Technological Institute (DTI) and the universities in Denmark play a crucial role in nurturing, breeding and developing the required new talent. All Danish universities offer relevant programs**.** Companies and universities in the cluster have open discussions about relevant education programs to ensure that they train the best and most qualified workforce. From the start of the cluster, the robotics sector has been driven by the ambition and expertise of innovative thinkers, largely emanating from universities like the University of Southern Denmark. The university’s growing global reputation has attracted the best talent from across the globe, thereby fueling innovation and excellence in Odense. Talented individuals from the university are also encouraged to pursue commercial innovation alongside their academic activities. The creation of spin-off companies is stimulated, with the assurance that their university positions will remain available should they choose to return.

Yet, the sector still faces significant challenges. 74% of the member companies of Odense Robotics identified shortage of qualified workforce one of the three main challenges to fully realize their innovation potential. In 2024, approx. 25% of Danish robotics companies were forced to abandon filling vacant positions due to a shortage of qualified applicants. Among these companies, a substantial 38% reported that their recruitment challenges are substantial enough to lead to production or revenue losses. Cluster companies actively collaborate with students to secure talent. This collaboration encompasses various aspects, including project collaborations, internships, and student jobs (*Odense Robotics, 2025*).

### 5.2.7 Innovation in product portfolio

Innovation is the key to growth and in 2024, two out of the three robotics companies in the Odense Robotics cluster launched new products, proving that the industry is committed to

staying ahead of the curve. Advancements in intelligent adaptive systems, interoperability, security, and simplification are the pivotal trend for the continued growth of the robotics sector in Denmark. Embracing AI and machine learning technologies is essential for developing solutions that cater to the needs of various markets (*Anderson et al, 2025*).

The Odense Robotics members say that in 2025 Artificial Intelligence continues to play a growing role in their forthcoming products and services. Furthermore, the companies are actively expanding into new markets such as healthcare, agriculture, and energy, thereby creating novel opportunities within a dynamic market landscape. The green transition and circular economy also present numerous opportunities. Denmark's robotics, automation, and drone companies play a crucial role as suppliers of technology to companies in the green industry, particularly within the wind energy sector and energy efficiency, but also reducing the $CO_2$ emissions and the use of materials (*Odense Robotics, 2024a, 2025*).

### 5.2.8 Patents

Danish companies are engaged in intense competition with their global counterparts in the pursuit of groundbreaking robotics innovations. Patent applications serve as a indicator of innovation activity. Over the past decade, the global number of yearly robotics-related patent applications has experienced remarkable growth, surging from less than 2,000 applications in 2010 to surpassing 37,000 applications in 2022. While the Danish robotics patent landscape has also witnessed significant progress during this period, its growth rate has been slightly slower compared to the global trend (Figure 4).

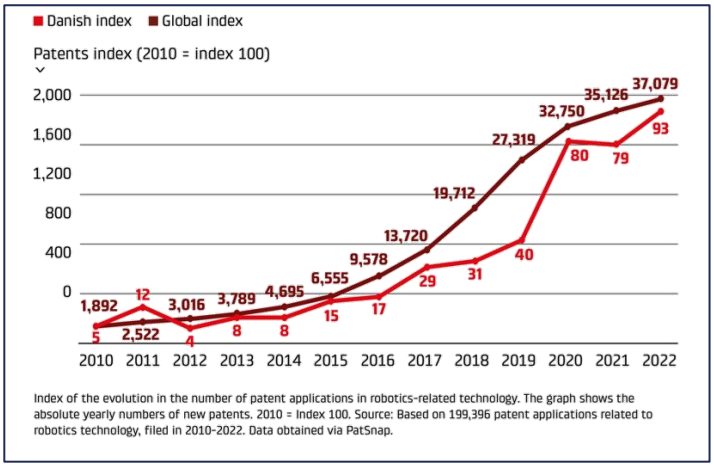



*FIGURE 4: Robotics patents in Denmark and globally, 2010-2022, Source: Anderson et al (2025).*

The number of patent applications per capita is an indication of a country's innovation, considering its population size. Denmark ranks seventh among European countries in terms of patent applications. While slightly ahead of the European average, Denmark trails behind the leading European countries, Sweden (23 patent applications per 100,000 inhabitants) and Switzerland (22 patents). Ireland, Germany, Finland, and the Netherlands are also all ahead of Denmark (Figure 5).

Figure 6 shows the diverse group of organizations leading the Danish robotics innovation from 2010 to 2022. Universal Robots and Mobile industrial Robots are at the top of the list. The ranking also includes the knowledge institutions Danish Technological Institute (DTI, 19 patent applications) and University of Copenhagen (7 patent applications). It's uncommon to find not-for-profit organizations ranking so high in patent application rankings, which are typically dominated by companies.

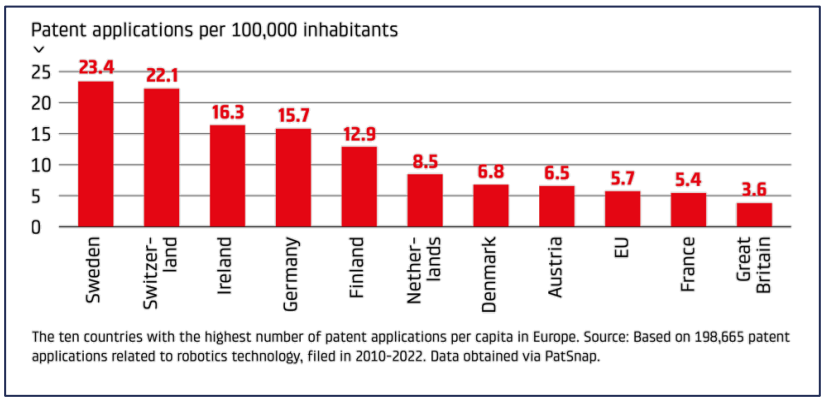



*FIGURE 5: The 10 European countries with the most robotics patent applications per 100,000 inhabitants, 2010-2022. Source: Anderson et al (2025).*

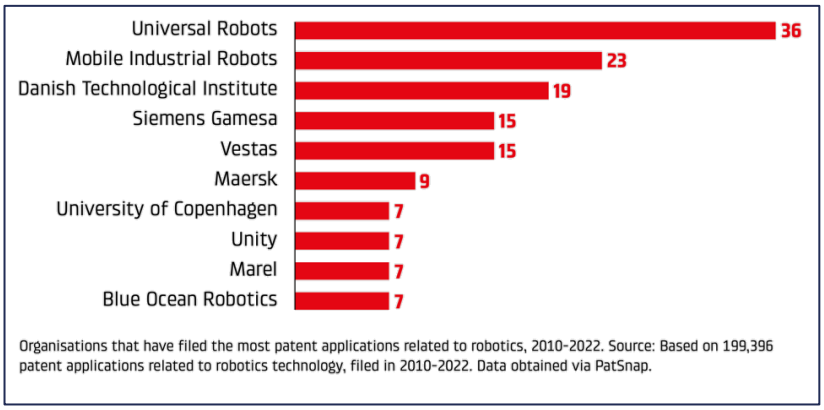



*FIGURE 6: The 10 Danish organizations that have applied for the most robotics patents, 2010-2022. Source: Anderson et al (2025).*

## 5.2.9 Acces2Funding

While innovative ideas for new robotics inventions are valuable, their practical implementation requires substantial capital investment. With the rapid expansion and global potential of many companies, external capital often becomes a necessity. One of the key factors in the success of the rapidly growing robotics cluster is the ability to raise capital and gain access to venture capital.

With its highly educated workforce, advanced infrastructure, and strong support from both public and private institutions, Denmark is an ideal spot for foreign companies and investors seeking to participate in the robotics revolution. In addition to the companies within the cluster, there has been a growing interest among business angels and institutional investors in scaling over the past few years. Nowadays, Odense is a top-notch robotics hub that beats other major European startup hubs in robotics investments year after year. From 2015 to 2024, over €1 billion has been invested in local robotics companies. Denmark is ranked number 1 in Europe when it comes to the number of venture capital rounds per person, and the third highest in terms of total venture-capital investment in robotics startups, with seed capital and early venture capital rounds being the most common types of funding (*Startup & Places, 2022; Invest in Odense, 2023a*).

In 2022, Denmark established the Odense Robotics StartUp Fund. The fund had secured $2.5 million USD in capital through donations from several of Denmark's most prominent robotics investors and corporations, as well as esteemed commercial foundations. The fund offers startups access to capital, specialized sector knowledge, and a robust incubation environment. Investments are made in the form of loans, which startups repay over time; they make a supplementary payment upon acquisition. These payments generate returns, which the fund subsequently utilizes to support new startups. Beyond receiving a loan, startups are also part of the incubator at Danish Technological Institute in Odense, where they have access to office space and advanced technical equipment within an innovative environment. Several of the fund's founders, accomplished successful robotics entrepreneurs, serve as mentors to the startups. This act of mentorship is viewed as a way to contribute to the community from which they emerged. They want to support the future startups not only financially but also through meaningful dialogue and mentorship (*RobotReport, 2022*). In 2024, the Financial Times recognized the Odense Robotics StartUp Fund as one of Europe's best startup hubs (*RobotReport, 2024d*).

Foundation year of Odense Robotics' member companies (in the year 2025).

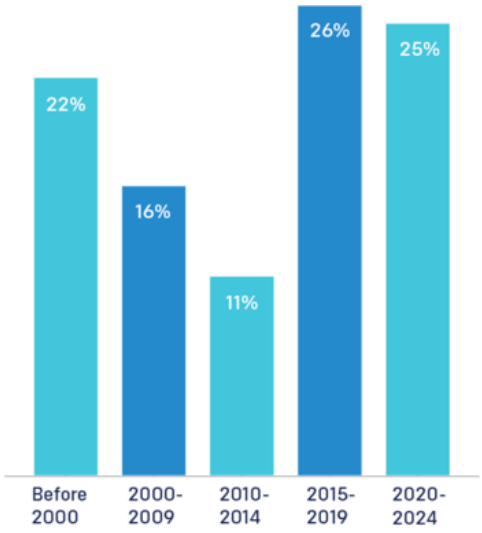



*FIGURE 7: Denmark's robotics industry is characterized by a high proportion of startups and scaleups. Source: Odense Robotics (2025).*

Denmark's robotics industry is characterized by a high proportion of startups and scaleups. 25% of the members of Odense Robotics in the year 2025 are established after 2020 (Figure 7). This hotbed of innovation bodes well for the industry's future development (*Odense Robotics, 2025*).

Odense's startup scene, the collaborative melting-pot of entrepreneurs, engineers, students, researchers and developers, shows how important re-investment cycles are. When the shipyard closed, the robotics team moved around. The South Denmark University played a crucial role in establishing Universal Robotics (UR). The MiR team was involved in the early stages of UR. When American Teradyne bought UR and MiR, many of their leaders became multi-millionaires. Those very same people subsequently reinvested a portion of their wealth in new ventures in Odense. That means that since the early days, exit capital from UR and MiR has circulated within the Odense-based robotics cluster. When substantial exit payments reach the hands of key individuals, they generate a cascading effect as the money is reinvested in potential new successes, expanding the robotics cluster. This approach eliminates the apprehension of being acquired by foreign entities. Exits simply create a breeding ground for promising new entrepreneurs and their companies. They foster a nurturing environment, leading to an abundance of new job opportunities, and both skills and talent remain in the area (*Invest in Odense, 2023a*). Odense's experience in nurturing a world-class robotics cluster through re-investment cycles of entrepreneurs who, upon exiting their companies, transition into investors has provided a blueprint on how to create well-functioning innovation ecosystems (*Startup & Places, 2022*). Nevertheless, while funding appears to be available, a survey of over 300 Danish robotics

companies revealed that 67% of them still face challenges due to a scarcity of capital (*RobotReport, 2024d*).

### 5.2.10 Test and Experimentation infrastructure

Within the Danish ecosystem, numerous full-scale test facilities are available for the development and testing of next-generation robotics. These field laboratories serve as inspiring environments that foster the development, testing, and deployment of robotics solutions by companies and research institutions. They provide a practical setting where individuals can gain hands-on experience in working with and utilizing novel technologies and approaches. From a European perspective, the following two instruments are important:

- The regional European Digital Innovation Hub ‘EDIH EDOcobot’ offers a range of services to help local SMEs with their challenges in digitalization and the deployment of collaborative robots (cobots) in many domains, specially manufacturing and logistics. Its 'Test-Before-Invest' program supports SMEs to automate their production processes. Independent experts provide advice on the processes that can be automated through robotics. The EDIH is also offering investment support and access to relevant networks and innovation programs (*EDOcobot, n.d.*).

  The EDIH EDOcobot has cooperation agreements with several other European EDIHs, e.g. with the EDIH BOOST Robotics East Netherlands, which has a focus on digitalization and robotics for the sectors manufacturing, agrifood, and health.

- The EDIHs' Test-Before-Invest focus is primarily on more mature robotics technology. The European TEFs (Test & Experimentation facilities for AI) focus on more innovative issues where substantial testing and validation are still needed. The TEF AI Matters, in which Odense is participating, has a focus on manufacturing and robotics. SMEs can apply for support for their future implementation of robotics. Through effective use of technology, important issues such as labor shortages can be addressed, better working conditions for staff can be created, and the quality of services can be raised.

## 5.3 ROLE OF THE REGIONAL AND NATIONAL GOVERNMENT

Robotics and automation are essential for future growth of economies by boosting productivity, catalyzing innovation, and creating new business opportunities. While economies globally are increasingly investing in robotics, each country has its own strategy (*RobotReport, 2024e, RobotReport, 2025*). Industrial policy involves establishing a framework within which businesses operate. It encompasses, for example, regulations and initiatives from the state and public sector to enhance business development and stimulate job creation.

The Danish robotics cluster stands as a remarkable example of a successful industrial cluster that emerged during a period of deindustrialization. It received significant support from public agencies and programs at pivotal moments, catalyzing its transformation into a remarkable industrial renaissance. From the initial collaboration between the shipyard and the university to the present national Odense Robotics cluster, public institutions have played a pivotal role in its development. The success of the robotics industry in Denmark's cluster can be attributed to the efforts of many talented and passionate individuals and entrepreneurs. However, for a cluster to flourish and grow, specific conditions must be in place. These conditions are the foundations upon which companies flourish. Public sector agents operated in various capacities at different levels. In the next section, we will be examining the role of local public actors and then delve into the national level. Much of the information is derived from an article by *Lamberty and Nevers (2022)*.

### 5.3.1 Regional level

The sequence of events leading to the robotics cluster commenced in the late 1980s at the local level, with the university playing a pivotal role. The vice-chancellor-initiated meetings between researchers and companies to identify joint project opportunities. After several years of collaboration, a university-shipyard joint venture company was established. Later, the company Maersk donated millions to the establishment of a research institute at the university, and the university had to contribute an equal amount. This at that time unusual close cooperation with a company, exemplifies the university's entrepreneurial mindset. The university's role in establishing the robotics cluster is evident.

The Odense Shipyard, the largest privately owned workplace in the Odense region with over 3,000 employees, abandoned its robotics research and later announced its closing. Local governmental organizations had not been actively involved in the robotics developments, but recognizing the potential loss of the ecosystem and related jobs, the Odense municipality and the county of Funen decided to take a more proactive approach. This policy shift coincided with the emergence of the concept of "industrial (high-tech) clusters" at the national level. Public funds were crucial to sustain the local robotics environment, as private companies were skeptical. The Odense municipality and the county of Funen viewed their investments as a means to foster the development of the robotics ecosystem, aiming to attract the needed much larger amounts of private capital. The region and municipality actively supported the establishment of a new network and center of competence, which effectively contributed to the retention of experts and their skills. Following an initial period of non-involvement, the public organizations assumed a significant role.

From 2000 to 2012, Odense witnessed almost 50% decline in industrial jobs. In response, the city was prepared to allocate substantial resources to develop and promote the robotics cluster. The success of Universal Robots served as a catalyst, inspiring Odense Robotics to craft a narrative of a thriving robotics business cluster. This narrative generated increased local awareness and paved the way for substantial investments from local sources. Odense Robotics is not a local industry entity; rather, it's a policy initiative established and funded by local governmental organizations with the objective of promoting, advancing, and organizing the local robotics industry.

Local public organization significantly contributed to the development of the Danish robotics cluster. The university has been a key player throughout the whole process. The municipality and other local political organizations shifted significantly from non-engagement to actively supporting the sector. These local actors assumed both a facilitative role and they invested resources in the development of selected innovative startups.

### 5.3.2 National Level

In 2001 the existing Danish Growth Fund became a governmental venture fund which was allowed to invest directly in promising SMEs. The Fund paves the way for the private market. The Growth Fund's financial stake within robotics companies has been followed by significant private investors from venture capital and angel investors. This realignment became crucial to the development of the Danish robotics. Universal Robots, later the crown jewel of the Danish robotics cluster, faced bankruptcy in 2008 due to depleted funds and lack of private capital. The Growth Fund, along with another fund, intervened and saved the company from financial ruin. By this direct investing, the state assumed the financial risks that private investors at the time were unwilling to undertake. This step has been essential for the emerging robotics cluster as the international renown cluster would probably not exist without Universal Robots. Beyond its administrative and regulatory functions, the state has emerged as an actor willing to take risks that businesses may not be willing to take. The investment marked a new way of working, as evidenced by the state's involvement in other robotics firms.

Another significant initiative of the Danish government was the establishment of the Globalization Fund in 2006 to boost innovative research and entrepreneurship. This program significantly increased funding for R&D, benefiting the robotics industry on Funen.

The creation of a national cluster strategy in 2013 was also important. The business cluster concept became part of Danish industrial policy; now it was possible to facilitate the development of the national cluster organization Odense Robotics. Prior to this, the Danish robotics cluster existed solely as an "organic" cluster without a formal entity organizing it. However, the Danish State was empowered to frame and facilitate the cluster's development through the Globalization Strategy and the national cluster strategy.

National legislation fostered an entrepreneurial mindset at universities, enabling them to establish an investment company that could invest in innovative startups based on university research. This increased freedom has led universities to become more actively involved in commercializing research, not only acting as facilitators but also directly investing in robotics companies. Science Ventures Denmark A/S was established in 2005, which has invested in several robotics companies, including Universal Robots.

In 2020, Denmark's government released an update on its national robotics strategy, promoting robot and automation use in SMEs to contribute to a sustainable future (*UFM, 2020*). The strategy established a good educational, research, and political framework for nationwide development and application of robot technology, legitimizing government support for research and development and co-financing company establishment in a hesitant market. The strategy included 11 focus areas, all contributing to sustainability and the green transition. Its main categories were (*Steno & Grouleff, 2020; Conpleks Robotics, 2020*):

(1) Research and innovation, including access to research infrastructures.
(2) Access to competences and skills.
(3) Internationalization, including EU Framework Program participation, foreign investor attraction, and customized export campaigns.
(4) Use of robot technology in Danish companies, including investments in knowledge and skills, and strengthened innovation through knowledge collaborations and networks

An area where government influence is more indirect, is in the social acceptance of robot technology. While education and information undoubtedly play a substantial role, government intervention is not the sole determinant. The Danish labor market is highly organized, and unions play a significant role. Despite negotiating the best possible conditions for their members, unions aren't afraid that robots will replace their jobs. In fact, some unions even encourage companies to introduce more robots to enhance their international competitiveness. This contrast sharply with some other European countries like France. The Danish labor market model and unions focus on protecting workers rather than specific jobs.

It is evident that public organizations significantly contributed to the Danish robotics cluster's development. They facilitated innovation and acted as risk agents when private investors were hesitant. Universal Robots' success story wouldn't have been possible without these public initiatives.

## 5.4 CONCLUSION

Denmark's successful establishment of a remarkable international position of strength in the field of innovative robotics, can inspire other countries. Robotics holds significant importance as a national technological and commercial strength in Denmark. Over the past 15 years, the industry has experienced substantial growth, leading to increased turnover and job creation. Today, Denmark boasts over 600 robot-automation-drone companies, employing a workforce of 19,500 people, with 14,900 working in Denmark and 4,600 abroad. The industry has consistently demonstrated stable growth and is internationally recognized as a leading global frontrunner in robotics.

It's evident that the establishment of the strong robotics ecosystem in Odense was not a mere coincidence. This ecosystem has a deep historical foundation, with its roots laid down many years ago and emerged through a decade of dedicated collaborative efforts between companies, the university, and local and regional governmental actors.

Odense's robotics ecosystem has deep roots in the city's steel and shipbuilding industries. The Odense Shipyard, renowned for constructing the largest container ships globally for its parent company, the A.P. Møller - Mærsk Group, led the way. Recognizing the need for welding robotic solutions, Mærsk invested in robotics research at the University of Southern Denmark, supporting the growth of the Mærsk Mc-Kinney Møller Institute. Over the years, hundreds of millions of Euros have been donated to this center.

Ship manufacturing shifted to Asia and the Odense Shipyard had to close its doors, leading to job losses in Odense. But the foundations for a robotics ecosystem were already in place, and this industrial decline paved the way for the development of the innovative robotics industry in Odense. The municipalities of Odense and Funen, along with the local university, with support from the national government, collectively invested in this robotics ecosystem. Visionaries, innovative entrepreneurs, mentors and governmental support organizations together shaped the cluster's technological trajectory and market focus. Technology, business development, and entrepreneurship intertwined in this perfect blend.

As a result, the closure of the shipyard didn't lead to a spiral of decline, but to the revitalization of the region. Numerous companies started, thrived, and grew from this fertile ground. The inspiring vibrant robotics ecosystem in Odense led to the creation of prominent companies like Universal Robots and Mobile Industrial Robots. Teradyne's acquisitions of these two companies put Odense on the world map, making it internationally recognized as a leading robotics ecosystem.

While the robotics industry experienced rapid growth in Odense, concurrent developments transpired in various other Danish regions. Simultaneously, several significant national initiatives were implemented, including a comprehensive national robotics program, a re-positioning of the Danish Growth Fund, and a national program to shape industrial clusters. Odense Robotics became Denmark's national robotics, automation, and drone cluster, headquartered in Odense with regional robotic hubs across the country. This national cluster played a crucial role in developing and promoting Denmark as an international hub for robotics. It supports the development of cutting-edge robotic technologies through collaboration among large industry,

startups, and academia. The city Odense spawned a cluster of robotics in with over 600 robotic companies nationwide.

Odense's robotics industry thrives due to its ecosystem, fostering collaboration between individuals and organizations and mutual support. Its success stems from an interdisciplinary approach, trust, a collaborative and entrepreneurial mindset, demanding customers, creativity, and a pro-robot population.

The local university played a pivotal role in the transformation of the Danish robotics cluster throughout the process. Also public organizations at both local and national levels contributed significantly. Local political organizations shifted from almost non-engagement to proactive support. Public institutions facilitated innovation and took risks when private investors were hesitant to take on such challenges. A success story like Universal Robots would not have been possible without these public initiatives.

The Danish robotics cluster stands as a remarkable example of a successful industrial cluster that emerged during a period of deindustrialization. Throughout its development, it received crucial support from public agencies and programs. It became a story of a great industrial rebirth, a remarkable industrial renaissance.

# 6. REGIONAL:
# TWENTE REGION ROBOTICS IN THE NETHERLANDS

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Adra-e WP4 T4.4 contribution
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*To tackle challenges such as climate change or the digital transformation, a multi-disciplinary approach and innovation is essential. Innovation thrives in successful ecosystems, but what elements define such environments? In this section, the Twente Region, renowned for its expertise in robotics, is examined in other to pinpoint defining characteristics of a successful regional ecosystem.*

# 6.1 THE TWENTE REGION

## 6.1.1 History and demographic background

To understand the key driving factors of the Twente region, we need to understand the historical background of this region, as well as the demographic characteristics of Twente. The region of Twente is situated in the east of the Netherlands, close to the German border and further away from the main capital of Amsterdam. This region is a so-called 'old industrial region'. These regions are characterized by an early industrial revolution that laid the basis for their heavy industry sectors such as textiles (Manchester UK, Twente NL, North-Pas-de-Calais FRA), coal and steel (Ruhr area FRG, West-Midlands, Upper-Silesia), and shipbuilding (Tyne, Wear, Pomorski Poland, Northern Jutland) followed by a spiral of decline since the second half of the 20th century due to the maturity and decline of these industries, ultimately leading to major company closures and job losses (*Benneworth et al, 2006; Cooke, 1995*).

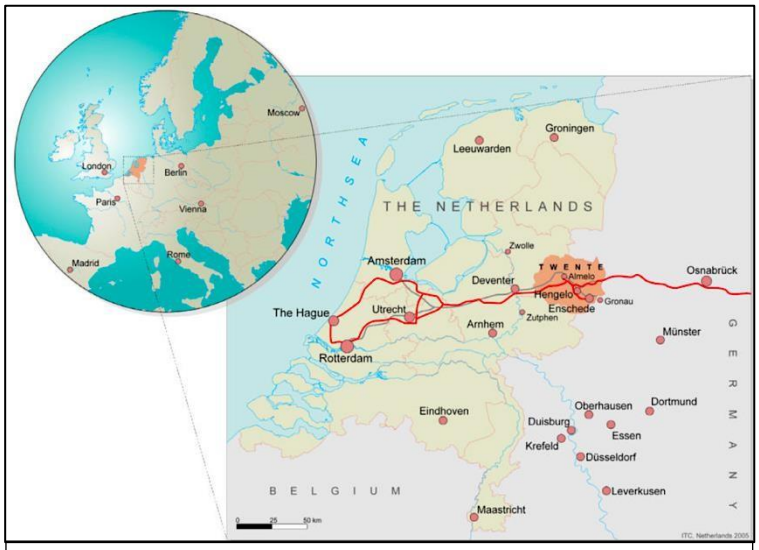


*FIGURE 1: Geographic map of the region Twente*

Until the 19th century, Twente was predominantly a rural region. During the winters, when farmers were unable to work in the fields, they turned to spinning and weaving, laying the foundation for the development of the regional clothing industry. After Belgium separated from the Netherlands in 1830, the Dutch government sought a location to establish a national textiles sector capable of producing cotton for overseas colonies. Recognizing the existing weaving expertise and knowledge, they chose Twente as the location for the growth of this textiles industry. In the cities of Almelo and Enschede, large textile factories were established, while the city of Hengelo focused on related metal, machinery, and electronics industries (*Sijkers et al., 2005*; Figure 1). Throughout the 19th and early 20th centuries, Twente experienced steady growth in textiles and metal manufacturing, which flourished for over a century.
The numerous factories in Twente produced mass products in textiles, specialized clothing and machinery, synthetic materials, and metal-electronic devices. With its countless factories, the region became a significant economic powerhouse, ranking as the second-largest textiles agglomeration globally, after Manchester (Figure 2; *Hospers and Benneworth, 2011*).

Since the 1950s, Twente's industry faced structural challenges. The regional textiles sector experienced a structural decline due to competition from low-wage countries, the loss of Dutch cotton colonies, increasing technological efficiency, and a lack of innovative entrepreneurship. By the late 1970s, most regional clothing factories had closed, and the textiles industry had

reached a crisis point, with employment falling to a quarter of its 1955 level. It became evident that the region required assistance in revitalizing its industrial decline, prompting a significant step forward (*Hospers and Benneworth, 2011*).

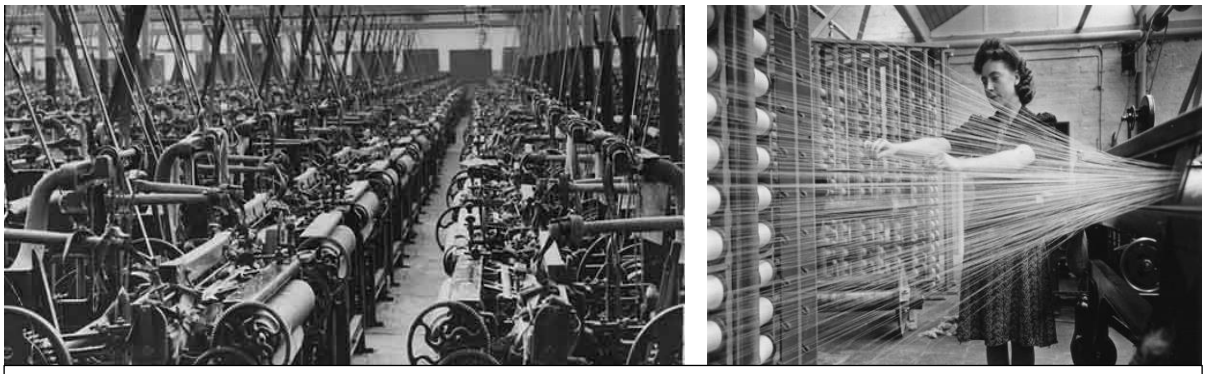

*FIGURE 2: Flourishing textile industry in the Twente region (Netherlands) during the 19th and 20th century.*

### 6.1.2 Innovation

The industrial decline, resulting in numerous job losses, spurred local stakeholders to initiate a campaign for national funding for a higher education institution to reinvigorate the region (referred to as 'The Experiment in the Wood' in translation; Figure 3). As a result, in 1961 the Technische Hogeschool Twente (THT) was founded in the city of Enschede (since 1986 known as the University of Twente; *Benneworth et al, 2006; Jongbloed, 2015*). The municipality of Enschede allocated the Drienerlo estate for the first campus-university of the Netherlands. This third Dutch university of technology offered degrees in mechanical, electronical and chemical engineering and applied physics and -mathematics (*University of Twente, n.d. 4*). The area's strong industrial heritage coupled with the establishment of this new technological university, marked the transition of the local economy into a modern technology-driven region. However, being a young university meant that the state contribution per student would be considerably lower compared to that of already established universities. These financial constraints, along with the imperative to further invigorate the local economy, prompted an innovative view of the university's role and position in society.


*FIGURE 3: The 'Experiment in the Wood' initiative formed the basis of the establishment in 1961 of a new Dutch university in the region Twente, which later came to be known as 'University of Twente - the entrepreneurial university'.*

As it became apparent during the 1970s that regional growth needed more than only technology, investments were made in new sectors such as services. At the same time, to turn the tide on static student numbers, the university reinvented itself as a regional academic institution, actively engaging local partners, and aiming to increase its regional impact by promoting spin-off businesses. The university positioned itself successfully with the slogan: 'University of Twente, the entrepreneurial university'. This entrepreneurial mindset extended beyond the strong emphasis on creating spin-off companies and also encompassed strategies and skills for collaboration with businesses. Therefore, the university established a fourth faculty, specializing in business and social sciences like management studies and public administration. In 1982, the university established the business incubator BTC (Business Technology Centre) adjacent to the campus. This incubator provided early-stage start-ups with accommodation and assisted them in their development. Since its opening, more than 700 young companies have used the services of BTC. Later, the university's technology transfer office created the TKT (Technology Circle Twente), which organized meetings between emerging entrepreneurs and representatives of larger regional firms and organizations *(BTC, n.d.; Groenman, 2001; Hospers and Benneworth, 2011; Jongbloed, 2015; Sijgers et al, 2005)*.

Similarly, other regional higher education institutions were established. These include the Hogeschool Oost Nederland (now known as Saxion University of Technology), the International Training Centre for geo-information sciences and earth observation (ITC, which is now part of the University of Twente), and the Academy of Arts AKI. Meanwhile, also more technologically focused joint research centers appeared on the scene. For example, the Centre for Mechatronics Twente, established in 1989, was very successful due to its close collaboration with machinery firms in Twente. After 2000, various collaborative initiatives emerged, including the establishment of Stichting Mechatronica Valley Twente (nowadays T-Valley). This organization was founded by regional firms, notably the renowned UT-spinoff Demcon, which secured funding to establish a chair in Mechatronic Design at the University of Twente (*Bennethworth et al, 2006; TValley, n.d.).*

As a result, the region successfully secured its third-ranking position among industrial regions, trailing only the Randstad and Eindhoven. This achievement was accompanied by a recovery and increased innovation across traditional sectors, particularly in food, metal/electronics, chemicals, advanced materials, and the defense industry. Key regional firms played a pivotal role in driving these developments. Furthermore, a new service sector emerged, primarily centered around knowledge-intensive technical services such as engineering services and transport logistics. Additionally, there was significant growth in innovative public services, particularly in healthcare. These developments were also reflected in the research and education programs of the university, which is nowadays world-wide known for its strong performance in medical technology, digitalization, robotics, and nanotechnology. Although the sector structure has become more balanced, most firms are SMEs. The region is well-known for its high number of start-up and spin-off companies. The number of internationally active growing companies is steadily increasing, and two successful unicorns (Booking.com and TakeAway.com), both founded by former students from the UT, are already born in the region (*Hospers and Bennewo2011; University of Twente, n.d. 2*).

### 6.1.3 Makers and Shapers

As highlighted by the previous sections, the region's historical background and demographic profile hold considerable significance. The establishment of a university added innovation and talent to the region. Nonetheless, the latter also highlights the fact that technical innovation alone is not sufficient. While scientific and technological research can lead to scientific impact. To have economic impact, a solid business plan is necessary. Yet even the most exceptional business plan cannot be implemented without public acceptance of the technologies or business models employed. This means that a collaboration is needed between Makers (academic or industrial technology developers) and Shapers (focused on business modeling, social acceptance, ethics, and legislation; Figure 4). This collaboration between Technology and ELSE (ethical, legal, social acceptance, and economic) disciplines, at the UT also called 'HighTech-HumanTouch', are the perfect building blocks for today's mission of the UT: 'We are the entrepreneurial university of technology, innovating to build a better world together'.


*FIGURE 4: 'Makers & Shapers' or 'Tech & ELSE' approach of the University of Twente to create, next to scientific and technological impact, also economic and social impact.*

While the entrepreneurial mindset at the UT and the inclusion of a social science faculty contribute to a multidisciplinary approach, the university is now undergoing its next transition as it moves from the third generation of universities, which emphasizes valorization, towards the fourth generation. Instead of merely bridging the gap between technology and society, the university aims to integrate society into the innovation process and co-create solutions to address complex problems, thereby making a tangible impact. This requires a significant change for researchers, fostering an outside-in approach to their work, as well as an integrated network and continual and structural funding opportunities.

### 6.1.4 Innovation instruments

Nowadays, the UT has earned a strong reputation for fostering the growth of start-up and scale-up companies, boasting a well-established ecosystem of incubators and accelerators, business developers, private investors and VC companies, and legal advisors in close proximity to the university. Since 1984, this has facilitated the creation of over 1,200 startups (more than 14,000 direct jobs; *University of Twente, n.d. 2*) – an achievement surpassing that of all other Dutch universities and ranking among the highest in Europe. A combination of innovation instruments was essential to stimulate the start-up and scale-up of these tech-based companies. Several of these instruments and programs will be discussed in this section.

One of the earliest programs was the TOP (Temporary Entrepreneurial Positions), the Netherlands' first official business incubator. This program aimed to support graduates and university personnel to start their own company by offering them both a technical mentor (often someone from the university) as well as a business mentor (often a successful entrepreneur), housing facilities for a period of one year (often close to the academic research group at the university), and a personal loan to stimulate calculated risk-taking and to bridge the gap between the academic idea and the first income from their start-up company. This successful means of fostering entrepreneurship, and variants of it, have been copied later in other regions across Europe. The program was originally created as a stand-alone activity. However, it has laid the basis for other measures in the region that aim to foster entrepreneurship. The program cohered over time into a mutually reinforcing network of regional activities. This remarkable achievement demonstrates the significant impact of the TOP Program on the Twente region, providing a small university with the chance to shine (*University of Twente, n.d. 3*).

In the Twente region, innovative knowledge-intensive SMEs now have access to finance at all stages of their development. This includes funding for proof-of-concepts and pre-venture loans, crowdfunding, and informal investing. Entrepreneurs and future entrepreneurs are also supported to pitch their ideas and concepts to investors. It's a nice balanced mix of regional and European public and private actors. Some of the funding options in the Twente region are listed in the Table 1.

*TABLE 1: Selection of the funding options in the Twente region (Source: TERRInet, n.d.)*

| **Instrument** | **Description** |
|---|---|
| Incubator BTC (Business Technological Center) – *(University)* | In 1985, the first BTC (Business Technological Center) incubator was established near the university campus to assist early-stage start-ups with accommodation and networking. Its success led later to the creation of dedicated NanoTech and MedTech incubators. |
| TOP and TOP Light, Dutch Student Investment Fund - *(University)* | Both programs assist entrepreneurial university employees in establishing their own knowledge-intensive companies. Participants receive diverse support and guidance, including technical and legal consultancy, throughout a one-year period. Additionally, they receive a personal pre-venture loan (up to 40,000 Euros) to foster an entrepreneurial mindset and encourage them to take calculated business risks. The Student Investment Fund, a fund exclusively for and by students of the two local universities, invests between 5 and 50 kEuro in startups. It assigns students to these startups who are working on internship or practical assignments. |
| Innovation Fund Twente – (*region)*, Innovation Fund Overijssel – *(Province)* | These governmental innovation funds invest in regional early-stage companies operating in the high-tech sector. There are two types of investments: growth stimulation Innovatiekrediet (25-75 kEuro) and Participations (100–2.500 kEuro). A pre-condition for the Participation part is that a private investor will co-invest under the same conditions. |

| | |
|---|---|
| Participation Fund Oost NL – *(Province)* | Participations up to 5 million Euros in innovative regional start-ups and scale-ups operating in the domains of one of the Dutch Top Sectors (e.g. ICT, High Tech Systems & Materials [including robotics]). |
| SME Innovation Vouchers – *(Province)* | The Province of Overijssel provides innovation vouchers to regional SMEs, enabling them to access technical and business support at Open Innovation Centers. |
| Angels Network Oost NL – *(Regional Private)* | Pitch-and-Match sessions are organized by the private business angels network to bring together teams of young enterprises and regional informal investors. The network provides financial investments along with hands-on coaching. Additionally, young entrepreneurs receive pitch training and business development support to prepare their companies for investor readiness. The network also organizes intake discussions for the European Angel Fund. |
| Twente Technology Fund (TTF) – *(Regional Private)* | TTF, an independent venture capital fund, invests in high-tech products and technology across various sectors, including ICT, clean technology, robotics, and biomedical technology. Their maximum investment per company is 2-3 million euros. |
| Informal Investment Services – (*National)* | ABN-AMRO bank provides access to 650 potential Dutch investors, who bring a wealth of knowledge, experience, as well as capital. |
| Cottonwood Technology Fund, EIT Digital – (*Europe)* | The European headquarters of the globally working (pre-)seed fund Cottonwood is located in Twente. Cottonwood invests in promising technological startups. The fund's portfolio primarily comprises companies operating in the fields of ICT, healthcare, robotics, clean energy, and advanced materials. |

Additionally, there is a coordinated effort among the UT, Saxion University of Applied Science, the municipality of the city Enschede, Regio Twente (a partnership of 14 municipalities in the region Twente), and the Province of Overijssel to cultivate the entrepreneurial climate across the entire region. They jointly founded Novel-T, a professional one-stop-shop offering extensive support, as well as running the operation of the regional business incubator and accelerator. Novel-T offers a well-organized integral support system, in which all instruments are available needed to advance entrepreneurship. It offers startups ('New Business') and innovative SMEs ('Next Business') access to the dynamic high-tech ecosystem to help them get off the ground, bridge the valley-of-dead, stimulate fast international growth and become international game changers. Within this ecosystem, the number of start-up companies that grow into successful companies is high, with a success rate of around 75% (*NovelT, n.d. 1*).

As demonstrated in the last example, instruments for fostering innovation need to extend beyond mere access to funding. Take, for instance, the Novel-T Legal Scan, which assists startups in identifying their crucial legal matters.

The Legal Advice Centre also offers guidance on Dutch corporate and company law. This includes information and advice on contracts, the optimal legal structure for the company, and the transfer of intellectual property rights to a spin-off entity. While the support is primarily focused on start-up companies, regional established entrepreneurs can also receive free assistance with knowledge-intensive ideas, products, or services (e.g., idea protection). The Centre's expertise lies primarily in the fields of corporate, company, and contract law, as well as intellectual property. To foster an entrepreneurial mindset and raise awareness about patents, the university has implemented a policy where, if a patent application is financially beneficial, one-third of the income generated will be distributed among the original investors (*TERRInet, n.d.*).

An intriguing development is the INCUBASE incubator established by the Student Union of the University of Twente in collaboration with regional professional ecosystem builder Novel-T in 2020. Its mission is to support entrepreneurial students of the two regional universities in the

development of their innovative business ideas. The Student Union empowers students to achieve more than just a degree, and being entrepreneurial is a prime example of this. The Student Union promotes the academic competencies and well-being of students at the University of Twente. The incubator uses an business model tailored to student-startups. INCUBASE about their 'gym for entrepreneurship': "*Just like in a gym, you come to INCUBASE to train. You have to build your startup to grow eventually. The enterprising students pay ten Euros a month for a membership. With this membership, the entrepreneurs can use the co-working space, the support of Novel-T and, for example, request subsidy advice from our partners Rabobank and PNO*" (*Student Union, n.d.; NovelT, n.d. 2*).

### 6.1.5 Talent development and creativity

Even with a promising idea, a solid business model, and ample support, establishing and growing a technology-driven business entails numerous steps, crucial for both the business itself and the prosperity of the region. Among these factors, the availability of skilled talent emerges as a crucial component. In the Twente region, several programs are available to equip young talent with the set of tools and competences essential for success in the field. Below and in Table 2, you'll find some programs designed to enhance business skills in the Twente Region.

In addition to fostering business skills, generating new ideas can be stimulated through various avenues. For instance, Pitch-and-Match meetings are used to share information about the university and business community, aiming to spark new collaborations. In these sessions, comprised of approximately 20 experts, discussions on emerging technological trends, future plans, and community cohesion take place, often leading to innovative collaborations and ideas. These meetings provide researchers with the opportunity to engage with a diverse audience of end-users and business experts. To stimulate community cohesion further, all spin-off companies over many years received a free one-year membership of Technology Circle Twente (TKT), a business club for high-tech companies with almost 200 members. Next to TKT, also other regional business clubs were founded by other players, e.g. IKT (Industry Circle Twente). These actions to orchestrate a renewed regional innovation approach also create the risk of operating too much as an 'regional island of innovation'. Though many stakeholders generated 'local buzz', they were not interacting enough with each-other nor with networks outside the region (*Benneworth et al, 2006*). Fortunately, this lock-in situation was recognized, and many business clubs and networks started to work more and more together, reducing the fragmentation developed during the years in the Twente business and innovation landscape.

Another effective method for generating fresh ideas is through creathons. These intensive brainstorming sessions, where participants are immersed for 24 to 48 hours, harness the power of well-crafted questions, a diverse group of individuals, a proven concept, a time constraint, and high levels of energy and enthusiasm. During creathons, teams collaborate to address social challenges, resulting in innovative and out-of-the-box ideas. While like hackathons, creathons differ in that they focus on generating physical products as outcomes. To enable the further development of the ideas into concrete products or services, the winning teams are matched to the Novel-T business developers.

*TABLE 2: Examples of programs designed to enhance business skills on the Twente region.*

| Instrument | Description |
|---|---|
| BSc: Entrepreneurship education programs at UT | The goal of this minor is to stimulate and develop an entrepreneurial and innovative attitude and knowledge. The program consists of academic and practical modules and offered specifically to non-business students. |
| MSc: International EIT Digital Master programs | These two-year programs enable students to study at two of the 16 universities located in two different European countries. These double degrees combine technical competencies with practical skills in innovation and entrepreneurship. |
| EngD: Engineering Doctorate at UT | This post-master two-year program seamlessly blends academic research with practical industry design by integrating university education with hands-on industry experience. During the practical phase of the program, students focus on working in industry on a challenging and innovative (and real problem) technological design project. They transfer knowledge and research results into industrial technological innovations and are supervised by both engineers from industry as university staff. After completion, students can use the academic title of Engineering Doctorate (PdEng). |
| ECIU University | ECIU University is an open European agora for solving multi-disciplinary societal challenges, doing research and learning for life. In this alliance of 14 universities, learners, teachers, and researchers work with cities, communities, and businesses to solve real-life multi-disciplinary challenges in entrepreneurial, innovative ways. |
| Start-up weekends, business-related workshops and knowledge sessions | In Twente region, various partners regularly host start-up weekends, providing aspiring entrepreneurs with the opportunity to explore their business ideas and learn the essential steps to turn them into reality. For instance, Novel-T frequently organizes workshops and knowledge sessions focused on entrepreneurship and knowledge protection. |
| Life-Long-Learning, Smart Industry BOOST masterclasses | In addition to the Life-Long-Learning modules offered by the two regional universities, the Smart Industry BOOST masterclasses offer advice also to students and (young) entrepreneurs to learn how to turn technology into business or increase the strategic and practical knowledge of SMEs. |

Despite the favorable reputation of Twente for innovation, the region lacks recognition as a vibrant creative hub among the general public. Many people associate Twente with textiles, natural landscapes, and vast open spaces, which has contributed to a perception that the region lacks appeal for the creative class. This is reflected in the region's lower-than-average proportion of individuals working in creative professions compared to the national average (main cities have almost 10% less). Yet, innovation requires a creative approach or the willingness to explore new approaches. While initiatives to foster collaboration between the technical university and the AKI Academy of Arts have been attempted, they have not consistently contributed to regional innovation processes.

### 6.1.6 Summary

The Twente region presents a compelling case of regional transformation, illustrating how historical adversity can serve as a catalyst for renewal. Once a thriving center of textile and metal industries, Twente experienced severe economic decline in the mid-20th century as global competition, technological shifts, and structural inefficiencies eroded its industrial base. However, this downturn spurred a determined and coordinated regional response that laid the groundwork for long-term revitalization.

A key milestone in Twente's transition was the establishment of the University of Twente, which not only infused the region with technical expertise and academic talent but also embraced a distinctly entrepreneurial mission. By promoting collaboration between technology developers ("Makers") and societal stakeholders ("Shapers"), the university fostered a new model of

innovation, integrating ethical, legal, and social dimensions into technological development. This HighTech-HumanTouch approach has become a cornerstone of the region's identity and strategy.

Over time, the innovation ecosystem around the university matured into one of the most effective in Europe. A wide array of instruments, such as incubators, funding programs, and talent development initiatives, support start-ups and scale-ups throughout their life cycle. The region's impressive startup survival rate, the emergence of unicorns like Booking.com and TakeAway.com, and the successful establishment of public-private initiatives like Novel-T all point to a thriving entrepreneurial climate.

Nonetheless, challenges remain. Twente still struggles with its public image as a dynamic and creative region. Despite its innovation credentials, the area continues to be perceived as rural and industrial, with relatively low representation of the creative sector. This disconnect highlights the need for stronger integration between technical innovation and creative disciplines.

Twente exemplifies how a region can reinvent itself by leveraging its industrial heritage, investing in education and innovation, and fostering a collaborative and entrepreneurial ecosystem. As the region now aspires to move toward a fourth-generation university model, it must continue to build inclusive networks, attract creative talent, and strengthen its identity as a global innovation leader rooted in local resilience.

## 6.2 DOMAIN-SPECIFIC INNOVATION SUPPORT: THE ROBOTICS TWENTE EXAMPLE

The previous chapter was about the generic innovation strategy of the Twente region, a strategy useful for a very broad spectrum of technological innovations. This chapter deals specifically with innovation in the Twente region with and through robotics technology.

In addition to generic innovation tools, specific technologies and application areas also require specific innovation tools. Patents play a different role in the (bio)medical domain than, for example, in the digital domain where often the time-to-market is much shorter, where new developments in technology follow each other much faster and where usually no long medical approval processes are required. And successful innovation based on current AI developments has other requirements. How does the Twente region meet the specific needs of the robotics domain?

### 6.2.1 Main public players in the robotics ecosystem of Twente

In Twente, many different organizations are working together on the development of new robot technology, from the knowledge institutions University of Twente and Saxion University of Applied Technology, and governmental organizations like SPACE53, to companies such as, for example, Demcon, Robor Electronics, and RIWO.

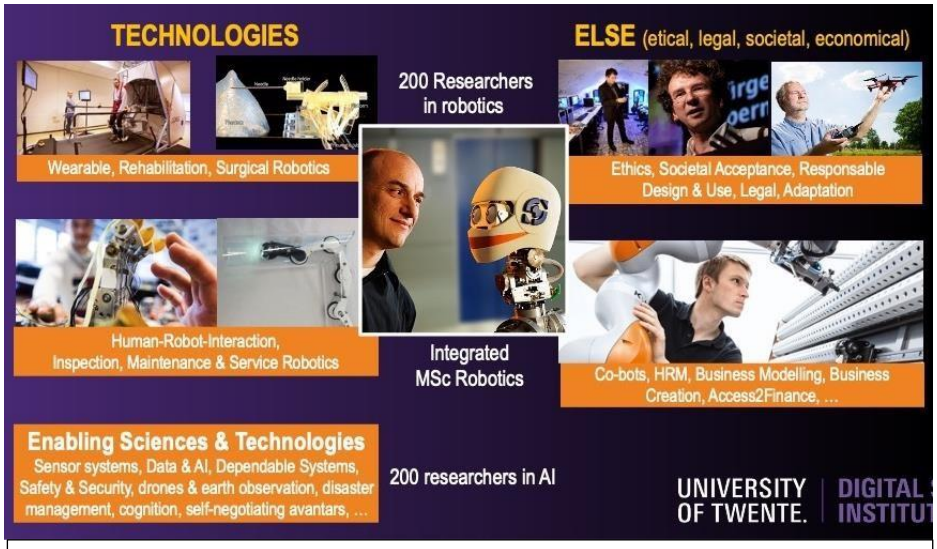


*FIGURE 5: The Twente Robotics of the University of Twente (NL): an integrated research and innovation approach combining both Makers (Tech) & Shapers (ELSE) disciplines.*

- ***University of Twente***
  The largest group of researchers, nearly 200 people, work at the Robotics Center (Figure 5; *University of Twente, n.d. 5*). The university has selected specific robotics application domains with high growth rates where much research and development are still needed:

healthcare, smart manufacturing (co-bots, precision manufacturing; not traditional robotics manufacturing), and social robotics. Within these domains is a strong interaction between the Tech Makers (technology developers) and the ELSE Shapers (business modeling, social acceptance, ethicists, and legal). There is also intense collaboration between the robotics developers and researchers of applied AI (physical AI or embedded AI; real-time AI). In this way, the more than 15 research groups can address all main aspects of modern robotics. For the development of integral solutions, they can address both technological (mechanics, electronics, sensing, control, actuation, human-machine-interaction, materials) and non-technological aspects (ethical, legal, economic, business, and social issues dealing with robotics when introducing them in daily life). Next to the Robotics Center, the Technical Medical Centre plays a crucial role in the development of medical robotics applications. Two of its focal areas are Biomedical Imaging and Bio-Robotics. This center maintains close working relations with many clinical partners, and they hold experimental facilities including an experimental hybrid OR, medical imaging labs, and wearable tech lab. This multidisciplinary approach at the UT, its network, its size, and its real-life testing facilities offer a unique fertile ground for the development of extraordinary robotic solutions and the investigation of their impact on human lives and society.

- ***Saxion University of Applied Technology***
  Saxion University of Applied Technology (*Saxion, n.d.*) aims to distinguish itself by establishing a reputation in the field of Living Technology. This involves looking at the interaction between technology and society. Within this field, Saxion focuses on three research themes: Areas & Living, Health & Wellbeing, and Smart Industry. The Smart Industry area concerns research in the field of HighTech Systems and Materials, including mechatronics and robotics, smart materials and ambient ICT.

- ***Space53***
  Space53, a public-private partnership, receives funding from governmental organizations such as the Province of Overijssel, Twente Safety Region, and the city of Enschede. Their primary focus is on developing, testing, and training of unmanned vehicles. Initially based at the former Twente airbase, they have expanded their testing facilities beyond controlled environments like the airbase to include less controlled settings like city neighborhoods. The Space53 drone innovation cluster has been part of Twente Airport since January 2025 (*Space53, n.d.*). The Living Smart Campus of the University of Twente seamlessly integrates these two types of environments.

- **TValley**
  TValley is a Smart Industry Field lab that focuses on the design of mechatronic and robotic systems. Established in 2001 as successor of the Foundation Mechatronics Valley Twente, the foundation has proven to be instrumental in enabling SMEs to scale up their operations. It also serves as a catalyst for more thematic-focused network initiatives, such as care, and inspection & maintenance. TValley's research and development roadmap encompasses unmanned systems, smart industrial systems, modular robotics, and systems engineering. By leveraging modular robotics and systems engineering, the consortium can speed up the R&D process from proof-of-concept to prototype to first series production (*TValley, n.d.*).

- **Regional Hospitals**
  The regional hospitals Zorg Groep Twente (ZGT) and Medisch Spectrum Twente (MST) contribute to the health of the people of the Dutch region Twente, in the form of prevention, diagnosis, treatment and nursing. Both hospitals are important clinical partners in many

healthcare robotics-related projects.

- **Roessingh RRD**
  Roessingh is the largest rehabilitation center in the Netherlands. As an internationally recognized scientific research institute, RRD (Roessingh Research and Development; *RRD, n.d.*) holds a unique position between the university and healthcare practice. RRD and the University of Twente collaborate on healthcare robotics to support rehabilitation, such as robots for gait training and robotic devices to support arms and hands. They use their expertise in motion analysis and the measurement of muscle activation to produce smart devices that correct or support the movements and position of the limbs. The guiding principle is always to apply advanced technology in a manner that is both effective, simple, and user-friendly for both patients and therapists. These applications extend beyond the treatment center to the patient's home.

### 6.2.2 Robotics-specific test facilities

For the development and testing of the next generation robotics, the university and its partners have created several unique integrated research, development, and testing ecosystems (Figure 6), where it is possible for both academic researchers and their (industrial) partners to move seamlessly from the in-house research labs to outdoor test- and experience facilities and near-real-life living labs.

- The regional partner SPACE53 offers an operational space for outdoor testing for drones and maintenance and inspection applications. It is a nice location for industrial testing with possible cooperation with first responders. Because of the availability of infrastructures such as storage tanks, pipe racks and windmills, it is possible to use the area for very realistic testing scenarios.

- For the development and testing of the next generation healthcare robotics, it is possible for both academic researchers and their (industrial) partners to move seamlessly from the research labs and simulated testbeds such as an experimental Hybrid OR and a living lab type II at the university to healthcare-specific test- and experience facilities in the region. A same cascade of research and test facilities is available for the rehabilitation domain.

- Field labs are inspiring environments where companies and research institutions develop, test, and deploy Smart Industry solutions. It is a practical environment where people can learn in practice to work with and use these new technologies and approaches. The Test-


*FIGURE 6: Integrated cascade of research, test and experimentation facilities in the Twente region*

before-Invest facilities of the regional European Digital Innovation Hub 'EDIH BOOST Robotics East Netherlands' (*University of Twente, n.d. 1; European Commission, n.d*. 4; Smart Industry, n.d.) play an important role to help the local SMEs with their robotics innovation challenges. In the EDIH BOOST Robotics East Netherlands, 11 cutting-edge Field labs and knowledge institutes have connected their powers to propel innovation through a multifaceted approach that encompasses diverse offerings. Among these offerings are skills building and training programs, test-before-invest projects, and investment support. This holistic approach nurtures a thriving robotics ecosystem. The EDIH sets its sights on the core pillars of 'Robotics & Sensing' within the region's most vital sectors: Manufacturing, Agrifood, and Health. The EDIH BOOST Robotics East Netherlands has cooperation agreements with several other European EDIHs with a similar technology and/or application focus, for example, the robotics-focused EDIH in Odense (Denmark).

Unfortunately, the region does not yet have strong ties to the European TEF Test & Experimentation facilities for AI that are important for robotics. The EDIHs' Test-Before-Invest focus is primarily on more mature robotics technology. The TEFs focus on more innovative issues where substantial testing and validation are still needed.

### 6.2.3 Domain-specific innovation chains, strategic partnering

Understanding the market structures and tailored business cases for robotics within specific market sectors are pivotal for achieving success. To swiftly introduce a solution to the market with a well-defined and clear "fit-for-purpose" rationale, it is essential to gather information from the entire value chain. This is because the technology required must align with both technical and safety standards pertinent to the domain. Involving end-users' input at the commencement of the development phase expedites market adoption and accelerates market uptake. This necessitates the engagement of robot developers and/or technology providers with, for instance, care professionals and patient-consumers during both the design and deployment phases to effectively address their specific requirements.

Many of these processes run more smoothly when a knowledge institution has strong connections with the various players involved in domain-specific innovation chains. Therefore, the University of Twente actively participates in several European networks that bring together these innovation-chain players. Some nice examples are discussed below.

- European-wide innovation networks such as DIH-HERO and RIMA Alliance are key-players to orchestrate domain-specific supply- and innovation chains.

  The European Digital Innovation Hubs network DIH-HERO, coordinated by the University of Twente, is dedicated to the field of Healthcare Robotics. By bridging the gap between businesses and healthcare stakeholders, the network facilitates the development of innovative products and services that cater to the diverse needs of healthcare systems across Europe. Moreover, DIH-HERO actively participates in the standardization of robotics in healthcare and in addressing the ethical, legal, and societal issues (*DIH-HERO, n.d.*).

  The RIMA Alliance, also a network of European Digital Innovation Hubs, facilitates collaboration and inspiration among key stakeholders in the Inspection & Maintenance robotics sectyor. Its aim is to catalyze innovation and accelerate the adoption of robotics within this domain (*RIMA, n.d.*).

- The two universities in Twente are also members of several European Public-Private-Partnerships (PPPs) that are important in finding innovation partners in the robotics domain. These PPPs include Adra (AI-Data-Robotics Association; www.adr-association.eu) with its Topic Groups, EFFRA, an industry-driven association focused on the research of European Factories of the Future (www.effra.eu), and euRobotics, a Brussels-based non-profit association for all European robotics styakeholders (www.eu-robotics.net).

- The University of Twente was also a founding member of EIT Digital, one of the Knowledge and Innovation Communities of the European Institute for Innovation and Technology. EIT Digital is the largest European digital innovation ecosystem. For over a decade, its CEO was a faculty member, and the currently the business director of the university's Digital Society Institute is a member of its Supervisory Board. EIT Digital provides the university with strong interaction with the significant ICT-based industry in Europe, access to a high-quality international graduate school, and facilitates the rapid international growth of high-tech research-based spin-off businesses (*EIT Digital, n.d.*).

  Since 2025, the university is also a member of EIT Manufacturing. Consequently, in addition to the digital domain, the manufacturing and robotics domains will be firmly integrated into a European innovation ecosystem.

In terms of infrastructure, the ecosystem has access to numerous research and testing facilities, both at the two local universities and several public-private organizations. Renowned robotics research groups at the universities collaborate closely with numerous companies, hospitals, and other relevant stakeholders, fostering innovation in and with robotics. This extensive vibrant network not only boasts strong connections within Twente but also extends to the relevant European ecosystems and players. Moreover, the region offers impressive business support for both established companies and young startups, including business incubators, accelerators, test facilities, business coaching, and access to funding. With its robust high-tech industry, the

many successful start-up companies, and thriving robotics community, Twente truly emerges as a breeding ground for next-generation robotics (Figure 7).

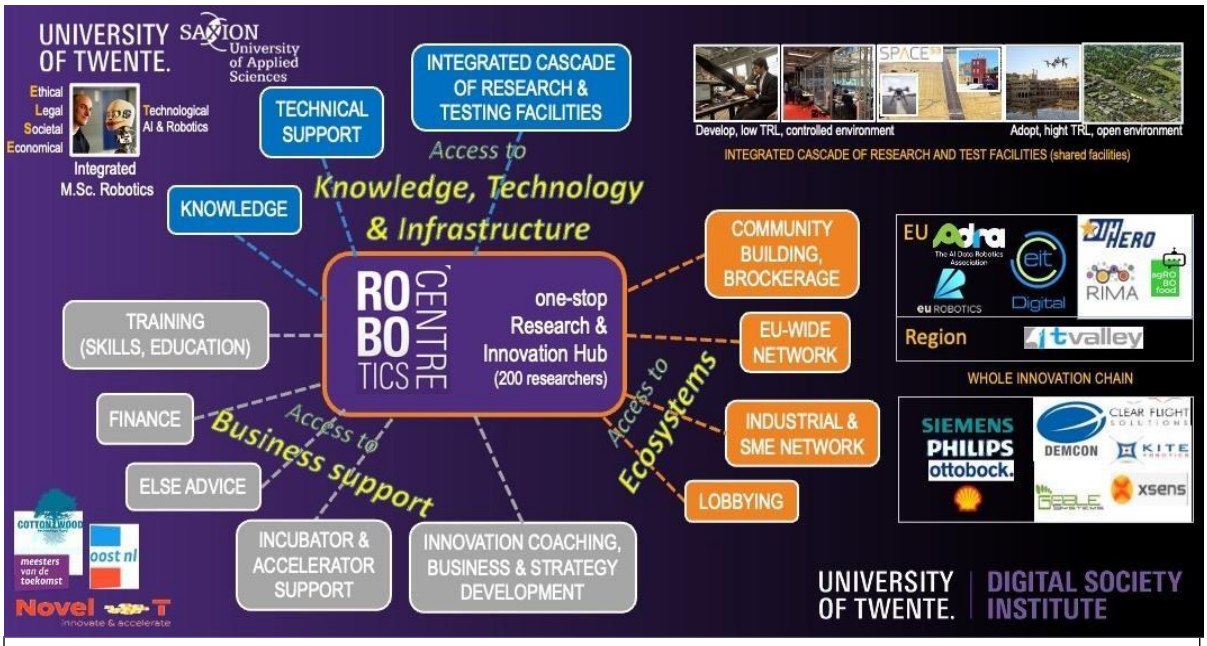


*FIGURE 7: Regional eco-system Twente Robotics*

## 6.3 NATIONAL DEVELOPMENTS

In the Netherlands, there have been several attempts to unite the country's robotics research and innovation activities. One initiative emerged in 2008, when robotics professor Stramigioli, design professor Van Houten, and Dennis Schipper, director of the high-tech mechatronics company and UT spin-off Demcon, founded the Advanced Robotics and Mechatronic Foundation Romech. Goal of the cooperation was to promote research and education in robotics and mechatronics. The foundation organized research and educational activities, conducted contract research, and promoted industrial applications and knowledge exchange.

In 2010, Romech underwent a transformation, becoming the "LEO Center for Service Robotics". This was the first robotics center in the Netherlands. It aimed to enhance the value chain for robotics by fostering collaboration between knowledge institutions, companies, and policymakers. The driving forces behind LEO were once again Stefano Stramigioli of the University of Twente and Dennis Schipper of the Enschede-based company Demcon. LEO encompassed member organizations that engaged in various stages of robotics development, including design, development, construction, testing, and marketing. It served as the network organization in the robotics field for the Eastern part of the Netherlands.

In 2010, Stramigioli also co-founded the national RoboNED platform, which functioned as the central coordinating body for all robotics activities in the Netherlands. To foster robotics development, synergize

different robotics fields, and align Dutch robotics research and development with market and political demands, the Dutch platform set three key objectives: (1) Bring together the various robotics fields and disciplines; (2) Stimulate the Dutch innovation ecosystem by uniting stakeholders from research, education, industry, government, and society; (3) Foster social acceptance of robotics in the Netherlands. RoboNED developed a joint Dutch Robotics Strategic Agenda, outlining a short-term, middle-term, and long-term vision for robotics development in the Netherlands and provided a roadmap for its progress. To ensure coverage of all required areas of expertise, RoboNED formed specialized groups that encompassed the entire field, from technology to psychology and robot ethics.

Despite multiple efforts to elevate robotics on the national policy agenda, unlike in countries such as Denmark, the promising developments in robotics have not been a high priority for the Dutch government (*Royakkers et al, 2012*). In 2017, when RoboValley, one of the participating parties in RoboNED, began positioning itself as the regional robotics hub of the Netherlands, the successful partnership RoboNED came to an end. HighTech NL, representing the Dutch high-tech industry, attempted to reconcile the fractured landscape through its Holland Robotics. Initially, several large industrial parties, six knowledge institutions, RoboValley, and High Tech NL collaborated on Holland Robotics. The organization sought to represent the entire robotics community in the Netherlands, encompassing both industry and academic researchers. However, it failed to gain widespread support and solidify into a robust national network. The former Holland Robotics has been rebranded as the HighTech NL Robotics cluster. Consequently, the Netherlands has several regions that excel in robotics research, yet it lacks a robust national joint robotics cluster.

## 6.4 UNIVERSITIES AS ORCHESTRATORS OF INOVATION ECOSYSTEM DEVELOPMENT

In response to government expectations, universities have broadened their interactions with their surroundings beyond their traditional roles in research and teaching. Some have even served as the primary orchestrators or keystones of nascent regional innovation ecosystems, as exemplified by the University of Twente. Keystone actors play a crucial role in these emerging ecosystems, providing the essential connections that hold them together. Universities interpret that role differently than firms, which influences the innovation ecosystems they each drive (*Mbitse et al, 2024*).

- ***Keystone universities*** can contribute to regional economic development through various mechanisms, such as spin-offs, research collaborations, and human capital (*Brekke, 2021*). They can articulate collective innovation goals aligned with regional needs and their orchestrate activities are constrained by regional boundaries. Universities can build unique cultures of entrepreneurship and cooperation, which can generate a “buzz” that attracts talent and new ventures to a region. They are uniquely positioned to establish regional innovation ecosystems with these characteristics.

- ***Keystone firms*** often seek to directly align the keystone role with their economic objectives by influencing the decisions of the ecosystem and shaping and managing it according to their innovation goals. Large firms often lack the same level of regional integration; they can transfer knowledge, capital, and employees between regions, even relocating if their economic objectives are compromised.

Universities are characterized by a greater consideration of regional needs, less driven by economic interests, and a stronger commitment to knowledge dissemination compared to their firm counterparts. They possess the unique ability to foster cultures of cooperation within ecosystems, as collective regional needs for them often outweigh individual economic goals. Innovation ecosystems driven by a keystone university are not burdened by a dominant firm that influences the ecosystem to align it with its own goals. Consequently, small firms and startups are likely to experience greater degrees of freedom in innovation (*Mbitse et al, 2024*).

The role of universities in regional innovation systems is evolving. Reichert describes the changing role of key actors in regional innovation systems and in particular those of the universities. Businesses and governments perceive universities and its members as ideally suited to “connect the dots” because they are impartial, driven by curiosity, and focused on long-term perspectives rather than commercial interests or short-term goals. As central players in a region, universities serve as key sources of knowledge and produce talent that can contribute to the region’s development. And as cultural actor they facilitate regional interaction and foster cooperative structures and engagement. ‘*The university provides three key pillars of regional development: knowledge, skills, and the ability to connect multiple disciplines, and institutional or sectoral perspectives. Universities become orchestrators of regional connectivity in all knowledge-intensive sectors’. ‘The central role of knowledge creation in post-industrial economies and societies has given universities a pivotal role in society. This move has changed the role of the university as the traditional hub of knowledge production, giving it a new twist. The university’s new centrality is inextricably intertwined with its role of orchestrating multi-actor innovation networks*’ (*Reichert, 2019*).

## 6.5 CONCLUSION

Twente, an old industrial region, underwent a significant economic restructuring. The university was specifically created as a key economic development institution to revitalize the region economically. The Twente region example serves as a compelling example on how a university can contribute to the renewal of old industrial areas. The positive outcomes demonstrate the significance of a long-term, stable actor like a university in transforming a declining industrial region into a dynamic and entrepreneurial one. These old industrial areas historically served as growth poles during the Industrial Revolution. However, structural change in such regions poses challenges. Nevertheless, a university can play a crucial role in breaking free from the past. The University of Twente has successfully embraced this role. It has been instrumental in building local networks and fostering connections with global developments. The university has acted as a growth node, generating new activities, particularly new businesses. These networks have grown over time, developed their own growth dynamics, and eventually become mutually reinforcing (*Benneworth et al, 2006*).

Universities traditionally strive to enhance and disseminate internationally relevant knowledge. However, today, there is an increasing expectation that universities actively participate in regional economic development. This involves fostering local employment, establishing new start-up companies, and stimulating economic growth. With people with a strong entrepreneurial vision and the introduction of the right innovation instruments, the university was able to achieve these goals. The region of Twente serves as a testament to the coexistence of local economic relevance and international excellence. Even in a young, underfunded university located in a

peripheral, economically depressed, and non-industrialized countryside, these objectives can be achieved (*Lazzeretti & Tavoletti, 2005*).

Every year, approximately 50 new enterprises emerge in Twente, showcasing the region's renewed innovation power. Among these successful regional start-ups and spin-offs are the unicorns Booking.com (now headquartered in Amsterdam) and TakeAway.com (still based in the region), and successful companies like DEMCON (an high-tech and industrial systems company that has grown to more than 700 employees with international operations and several subsidiary locations in the Netherlands and Germany), XSENS (a sensor suit company active in the movie, gaming, and rehabilitation sectors), SecurityMatters (a cybersecurity company which is also very active in the USA), and NoWiresNeeded (one of the pioneers of WiFi technology).

The robotics ecosystem in the region is robust. However, the economic restructuring of the region was not initially focused on robotics. In the beginning, the region's renewal was centered around developing a generic high-tech innovation ecosystem. Later, domain-specific instruments were added to these generic innovation instruments to support the robotics sector. This approach differs from, for instance, the economic restructuring in Odense, Denmark, which has been dedicated to the robotics sector from the very beginning.

In the Netherlands, there have been several attempts to unite the country's robotics research and innovation efforts, but these efforts have not been particularly successful. Consequently, the Netherlands has several regions that excel in robotics research, yet it lacks a robust national joint robotics cluster. This fragmentation limits the country's overall impact in the field. Nonetheless, regions like Twente have managed to build strong, independent ecosystem that serve as a leader in robotics innovation.

The ecosystem in Twente has access to numerous robotics research and test facilities. Internationally renowned robotics research groups at the universities collaborate closely with numerous companies, hospitals, and other relevant stakeholders, driving innovation in robotics. This extensive and vibrant network not only fosters strong connections within Twente but also extends to the relevant European ecosystems and players. The region provides an impressive and broad palette of business support for both established companies and young startups.

With its robust high-tech industry, numerous successful start-up companies, and thriving robotics community, Twente truly emerges as a breeding ground for next-generation robotics. While the case of the Twente region stands alone, its experiences could serve as a valuable inspiration source for regions with a similar socio-economic structure.

# 7. NATIONAL: AI STRATEGY CROATIA

Author: Lorena Baric
Adra-e WP4 T4.4 contribution
Date: 2025-05-22

*Some European countries had already crafted their national AI strategy by 2017.*
*Others, like Croatia, are still working on it. In the meantime,*
*Croatia has already established a well-connected and innovative AI ecosystem.*
*All thanks to a bottom-up approach, rather than relying on a top-down approach.*
*And they've got multiple unicorns as a result. How did this relatively small European country achieve this? How were the various stakeholders brought together? What tools did they use to strike a balance between economic growth through AI innovation and social well-being?*

## 7.1. INTRODUCTION

*Croatia's AI innovation landscape is driven by a strong grassroots ecosystem led by CroAI, the Croatian Association for Artificial Intelligence. At present there is an absence of a formal national AI strategy, a community-centric approach focusing on cross-sector collaboration, public education, policy engagement, and EU-level project involvement has been led by CroAI. CroAI plays a pivotal role as a mediator between startups, innovators, companies, academia, policymakers, and the public, contributing to EU AI policy, driving national awareness regarding AI, and engaging students, teachers, and the general public through various education initiatives. This model, while decentralized, offers a people-first template for innovation in smaller nations.*

Artificial Intelligence (AI), data, and robotics are rapidly transforming economies and societies. Like other European countries, Croatia is navigating between seizing the innovation potential of these technologies and ensuring they are applied in a human-centered, ethical, and inclusive way.

Croatia has emerged as a dynamic player in the European AI landscape, demonstrating significant potential despite being a relatively small country with 3.8 million citizens. The Croatian AI ecosystem has shown remarkable growth in recent years, with a vibrant community of startups, scaleups, established companies, academic institutions, and public organizations. Croatia currently has three unicorns. Two companies, Infobip and Rimac Automobili have achieved unicorn status with valuations exceeding 1billion USD, while Photomath was acquired by Google, further solidifying Croatia's presence in the global tech landscape. These companies have made significant contributions to the Croatian tech ecosystem. It is important to note that, considering the value of unicorns relative to national GDP, Croatia ranks exceptionally high. i.e. Croatia is ranked 11th place in the world for unicorns by this metric. This high ranking highlights the significant impact these two unicorns have relative to the size of Croatia's economy. Although Croatia lacks a formalized national AI strategy, a strong grassroots movement led by civil society, startups, and thought leaders has fueled the emergence of a vibrant AI innovation model. Central to this is the Croatian Association for Artificial Intelligence (CroAI), which has played a pivotal role in shaping the national approach.

This document reflects on how Croatia's innovation ecosystem has evolved – not from top-down policy directives, but from community-led efforts focused on dialogue, experimentation, and inclusion.

## 7.2 CROATIA'S BOTTOM-UP APPROACH TO AI INNOVATION

### 7.2.1 Early Initiatives and Ecosystem Building

Unlike many European countries that began developing formal AI strategies around 2018-2019, Croatia's approach to AI policy initially took shape through industry-led initiatives rather than government-directed programs. The establishment of CroAI in 2019 marked a pivotal moment in organizing the country's AI ecosystem.

CroAI was founded with the recognition that Croatia had numerous assets such as talented engineers, good academia, successful scaleups, and startups, but these elements were not well connected. The association adopted an inclusive approach from the outset, bringing together stakeholders from across the spectrum: startups, scaleups, SMEs, big tech companies, NGOs, universities, hospitals, law offices, teachers, students, visionaries and creative agencies. This broad membership was key in leading Croatia's participation in the AI-revolution, a transformative technology that impacts every sphere of life.

### 7.2.2 Policy Engagement and European Influence

CroAI's first strategic intervention came in 2020, during the consultation on the European Commission's White Paper on AI. Despite being a new organization, CroAI submitted extensive comments focused on innovation sandboxes, startup incentives, and ecosystem development, some of which were considered in the White paper. This success marked a turning point, demonstrating that bottom-up actors could shape European policy.

Recognizing a broader need to mediate between policymakers and technologists, CroAI co-founded the ***European AI Forum*** - a platform that brings together national AI associations and acts as a bridge between tech and regulation. Hosted for the first time during Croatia's 2020 EU Presidency, the Forum has since evolved into a Brussels-based independent platform with members across Europe (*European AI Forum, n.d.*).

What began as a collaboration between AI associations from Croatia, Germany, and France has expanded to include organizations from Austria, Poland, the Netherlands, Slovenia, Lithuania, and other countries, eventually establishing itself as a separate body based in Brussels.

### 7.2.3 National AI Strategy Development

Currently, Croatia does not have a national AI strategy, however, more recently, in May 2025, it was announced that Croatia would initiate the development of a National Artificial Intelligence Development Plan for the period up to 2032, along with a corresponding Action Plan for 2026–2028. According to the Ministry of Justice, Public Administration and Digital Transformation, this plan is expected to be based on three pillars: defining public policies, investment, and the application of artificial intelligence. The development process will involve government bodies, the civil and private sectors, and the academic community, focusing on areas such as education and skill development, digitalization of the private sector, financial incentives, and the protection of citizens' rights and privacy. CroAI is one of the stakeholders invited in the working group as it brings knowledge and a community-based insight to the process.

## 7.3 CROAI AS AN EXAMPLE OF GOOD PRACTICE

When founded in 2019, CroAI had the vision of positioning Croatia as "one of the leading destinations for research and development of solutions based on artificial intelligence". Its mission statement emphasized ensuring that "Croatia makes a significant contribution to shaping a better world" through AI. This focus on both economic opportunity and broader societal impact has guided the association's approach to ecosystem building.

***Croatian Artificial Intelligence Association Model***

CroAI emerged from the private sector (the founders of the organization are companies / startups) but has established strong connections with public institutions, academia, and civil society. The association's governance structure reflects its broad stakeholder engagement. The CroAI Board includes diverse professionals: entrepreneurs, executives, art managers, educators, and founders of successful Croatian tech companies. This diversity enables the association to address AI development from multiple perspectives, not just technical ones.

### 7.3.1 Funding Model and Sustainability

CroAI's funding model has evolved over time. When the association started, its only funding came from membership fees, which provided extremely limited resources. To expand its activities, CroAI began participating in European projects under programs such as Horizon Europe, Erasmus+, COSME, and initiatives related to European Digital Innovation Hubs.
The association's governance structure reflects its broad stakeholder engagement. The CroAI Board includes diverse professionals: entrepreneurs, executives, art managers, educators, and founders of successful Croatian tech companies. This diversity enables the association to address AI development from multiple perspectives, not just technical ones.

### 7.3.2 Community Building as a Systemic Tool

Community building represents one of the two main pillars of CroAI's strategy. The association has succeeded in bringing together over 450 members from diverse backgrounds, including teachers, artists, engineers, scientists, humanists, entrepreneurs, students, journalists, politicians, lawyers, and doctors. This broad membership base creates a multidisciplinary environment conducive to innovation and cross-pollination of ideas.

***Key community building initiatives include:***

- *Conferences and Monthly Meetups* - CroAI organizes regular gatherings that bring together people from different backgrounds and perspectives, including engineers, entrepreneurs, researchers, scientists, teachers, artists, doctors, politicians, and policy-makers, and others. These events facilitate networking and knowledge sharing, making future business collaborations easier as participants are already acquainted with each other.

- *Micro Communities* - CroAI has established specialized communities around specific topics, such as machine learning, product development, marketing, and DevOps. These groups hold weekly events on their respective topics, creating hubs where members can share experiences and learn from each other's mistakes.
- *Fight Club* - This unique initiative brings together the smartest people from Croatia to discuss challenging topics related to AI, such as "who will take blame if AI makes the wrong decision?" or "does Croatia need moonshot projects?".

- *Regional Meetups* - CroAI organizes meetups across Croatia helping to extend the AI community beyond major urban centers.

### 7.3.3 Education and Skills Development

Education forms the second pillar of CroAI's strategy, focusing on building public awareness and understanding of AI opportunities.

***Notable educational initiatives include:***

- *Elements of AI* - CroAI introduced this course, originally from Finland to Croatia and launched a vast campaign that reached 1% of the entire Croatian population. This initiative aimed to provide basic AI literacy to a broad segment of the population.

- *Heroes Project* - Launched in response to the emergence of ChatGPT and the resulting changes in educational systems, this project brings professionals from the CroAI ecosystem—including art managers, project managers, founders of AI startups, and corporate representatives—to Croatian high schools. They share their experiences of how technology has impacted their lives and how AI will affect various fields like medicine and law.

- *"AI se educiraj."* – a foundational AI course intended for teachers to support them in understanding AI and using AI tools to enhance learner experience. The course is implemented throughout Croatia.

## 7.4 REGULATORY AND INNOVATION FRAMEWORKS

### 7.4.1 AI Sandbox

Regulatory sandboxes have emerged as an important tool for promoting AI innovation while ensuring appropriate safeguards. A regulatory sandbox allows for the testing of innovative AI products in a real-world setting, with relaxed regulatory requirements, on a time-limited basis, at a smaller scale, and with appropriate safeguards in place.

In Croatia, there has been growing interest in establishing an AI Sandbox. In October 2021, CroAI presented discussions about creating a national AI Sandbox to provide a safe environment for developing and implementing AI that is flexible enough to create new startups and globally competitive solutions. More recently, with the EU AI Act requiring each Member State to establish at least one AI regulatory sandbox at the national level by August 2026, Croatia is preparing to meet this obligation.

### 7.4.2 AI Landscape Mapping

To better understand and visualize the Croatian AI ecosystem, CroAI has undertaken regular mapping of the ecosystem. The first AI landscape mapping was conducted in 2020, identifying approximately 70 AI startups among a total of 250 companies, universities, and other organizations in the ecosystem. Most recently, in 2025, the last iteration of the landscape registered more than 100 startups amongst over 500 players in the AI ecosystem.

These mapping exercises provide valuable insights into the ecosystem's composition and evolution. For instance, the 2021 mapping (AI Landscape 2.0) revealed that about 80 percent of AI startups were in Zagreb and the surrounding area, and women represented approximately 14 percent of founders or co-founders (*CroAI, n.d. 2*).

## 7.5 EUROPEAN CONNECTIONS AND INTERNATIONAL POSITIONING, PARTICIPATION IN EUROPEAN INITIATIVES

Croatia's AI ecosystem is increasingly integrated with broader European networks and initiatives. This connection is crucial for accessing resources, knowledge, and markets beyond the country's borders.

***Key European connections include:***

- *Adra (AI-Data-Robotics Association)* - CroAI collaborates with Adra-e on building a sustainable European technological ecosystem, focusing on creating trustworthy artificial intelligence and robotic technologies aligned with EU values. The Regional Ecosystem Event held in Zagreb in December 2024 highlighted the region's strengths in tech innovation and fostered cross-border collaboration.

- *EU AI Act Implementation* - Croatia is preparing for the implementation of the EU AI Act, which was announced in April 2021. The focus is on ensuring human rights protection and preventing discrimination through appropriate legal regulations.

- *European Digital Innovation Hubs (EDIHs)* – Croatia hosts 4 EDIH's with CroAI actively taking part in AI4Health.Cro, an EDIH focused on smart healthcare.

## 7.6 CONCLUSION

Croatia has established a dynamic and growing AI ecosystem that demonstrates significant potential despite the country's relatively small size. The formation of CroAI in 2019 marked a pivotal moment in organizing this ecosystem, creating a platform for collaboration across sectors and disciplines. Through its pillars of community building and education, CroAI has succeeded in bringing together diverse stakeholders and raising awareness about AI opportunities among the general population.

With the unicorn successes in Croatia, with companies like Photomath, Rimac, and Infobip gaining international recognition. The acquisition of Photomath by Google represents not only a significant financial exit but also Google's establishment of an R&D center in Croatia focused on AI. Still, there are some challenges remaining, such as the absence of a National AI Strategy.

The Croatian model of AI innovation is not built around infrastructure or investment volumes – but around people.

***Looking forward, Croatia's AI ecosystem has several opportunities for growth and development:***

- *Strategic planning* - The forthcoming National AI Development Plan offers an opportunity to establish a clear vision and roadmap for AI development in Croatia, aligning various initiatives and stakeholders around common goals.

- *European integration* - Deeper integration with European networks and initiatives, particularly through the implementation of the EU AI Act and participation in projects like Adra-e or DeployAI, can provide resources, knowledge, and markets for Croatian AI innovations.

- *Regulatory Innovation* - The establishment of AI regulatory sandboxes, both at the national level as required by the EU AI Act and potentially at local and regional levels, can create environments conducive to innovation while ensuring appropriate safeguards.

- *Ecosystem Diversification* - Efforts to expand the AI ecosystem beyond capital cities, increase gender diversity among founders, and support a broader range of sectors can enhance the resilience and creativity of the ecosystem.

- *Education and Skills Development* - Building on successful initiatives like Elements of AI, AI se educiraj, and the Heroes Project can help develop the talent pipeline necessary for sustained growth in the AI sector.

Croatia's journey in AI development illustrates that even smaller countries can make significant contributions to the global AI landscape when they mobilize diverse stakeholders, foster a culture of dialogue and innovation, and connect with international networks. As AI continues to evolve as a systems technology with far-reaching implications, Croatia's experiences offer valuable insights for other countries seeking to develop their own AI ecosystems in a way that

balances innovation with responsibility, economic growth with societal well-being, and national priorities with international collaboration.

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# 8. NATIONAL AI STRATEGY THE NETHERLANDS

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Adra-e WP4 T4.4 contribution
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*Artificial Intelligence (AI) has evolved into a systems technology that enables numerous other innovations. The potential of AI has been widely recognized, prompting numerous countries to develop strategies and programs focused on AI research and innovation. There is no universally applicable model for a national AI strategy. Developing and maintaining a national AI strategy is a continuous process of reflection, discussion, and adaptation, and countries can learn from each other's approaches. How did that process work out in the Netherlands? What role did the national government play? What choices have been made? What are the most important generic and AI-dedicated instruments to stimulate the national AI Research and Innovation agenda?*

# 8.1 DEVELOPMENT OF THE DUTCH AI STRATEGY

AI's influence on society has never been more pronounced. AI is increasingly embedded in everyday life, and it is poised to be the most transformative technology of the 21st century (*Maslej et al, 2025*). The Netherlands, with its strong overall starting position, can seize the opportunities presented by AI. However, several necessary steps had to be taken to achieve this. The Netherlands is a prosperous country with a high quality of life, a robust economy, a well-developed education system, a significant research presence, an open inclusive society and a strong physical and digital infrastructure. At the same time, the country faces the challenge of strengthening its competitive position in AI and innovative strength. The adoption of AI by governments and businesses, particularly SMEs, is too slow. The country is struggling to retain and attract AI (top)talent, and the AI startup ecosystem generates too few scale-ups. Dutch universities still have a strong position and can compete well internationally in AI research. However, the flow of research results through innovation to application needs to be significantly improved.

> *"AI is a civilization-changing technology, not confined to any one sector, but transforming every industry it touches".*
>
> Russell Wald, in the HAI AI Index 2025 (Maslej, 2025)

## 8.1.1 Toward a joint national AI strategy

The potential of AI prompting numerous countries to develop strategies and programs focused on AI research and innovation. In the years 2017 and 2018, governments from countries such as Japan, Singapore, China, Canada, Finland, France and the UK released strategies on AI (*OECD, 2021*).

Also in the Netherlands, in 2018 AI emerged as a distinct policy concern, recognized as one of the Dutch "key enabling technologies." The industrial organization VNO-NCW, the academic world ICAI (Innovation Centers for AI), the Top Team Dutch Digital Delta (cooperation between companies, academia, government), and the Dutch Organization for Scientific Research NWO published a call-to-action which aimed to safeguard the Netherlands' position within the global AI race. Under the guidance of the Ministry of Economic Affairs and together with several other initiatives such as the 'Artificial intelligence Research Agenda for the Netherlands, and ICAI Labs (Innovation Centers for AI), this formed the start of the first official AI strategy of the Dutch government in 2019, titled the "Strategic Action Plan for Artificial Intelligence" SAPAI (*AINED, 2018; Ministerie van Economische Zaken, 2019; NWO, 2019*).

The primary actions outlined in this national strategic action plan for AI were: (1) Capitalizing on societal and economic opportunities: Recognizing the opportunities, fostering AI entrepreneurship, and optimizing the utilization of AI within the public sector; (2) Establishing the required framework conditions, including research & innovation, education & skills development, access to data, and digital connectivity; (3) Strengthening the foundational elements: safeguarding public values, promoting responsible and trustworthy AI usage, ensuring consumer protection and the safety of citizens, businesses, and governments.

The strategy was accompanied by policy letters addressing public values and human rights. The Netherlands Scientific Council for Government Policy (WRR) recognized AI's transformative potential for society, publishing an advice on its application within the public sector in 2021. To ensure the effective implementation of the national AI policy, responsibility was shared among several ministries, highlighting AI's significant role in various policy areas. The intended implementation actions outlined in the national AI strategy included the establishment of the national PPP NLAIC (Netherlands AI Coalition) and the drafting of a strategic research, development and innovation investment program for the Netherlands that evolved into the national AiNed program (*Bakker et al, 2021; Ministerie van Economische Zaken, 2019; WRR, 2021).*

> *"The IMF has calculated that in developed economies around sixty percent of jobs may be affected by AI ... This calls for a government that has ambition and vision, based on public values and our goals".*
>
> Alexandra van Huffelen (source: *Rijksoverheid, 2024*)

To realize a strong values-driven AI ecosystem, the Dutch government stimulated cooperation, for example through the NLAIC. In addition, they created the preconditions for the development and use of AI applications. In November 2023, the government decided to finance the development of an own Dutch open language model in line with public values. In January 2024, the government presented its vision on generative AI. They also asked the Dutch Social and Economic Council (SER) to analyze the impact of AI on labor productivity, quantity and quality of work. In addition, the government decided to conduct campaigns to explain to citizens how to protect data from training generative AI models, to explore the establishment of a safe and usable public national AI test facility, and setting-up a national AI validation team that will assess, for example, available AI applications for non-discrimination (*Ministerie van Binnenlandse Zaken, 2024; Rijksoverheid, 2024*).

Since January 1, 2025, the two main Dutch instruments NLAIC and AiNed have joint forces under the name "AI Coalition 4 Netherlands" (AIC4NL) to further reduce fragmentation and to even more strongly shape the national AI Research & Innovation agenda (*AIC4NL, 2024; Jonker, 2025*).

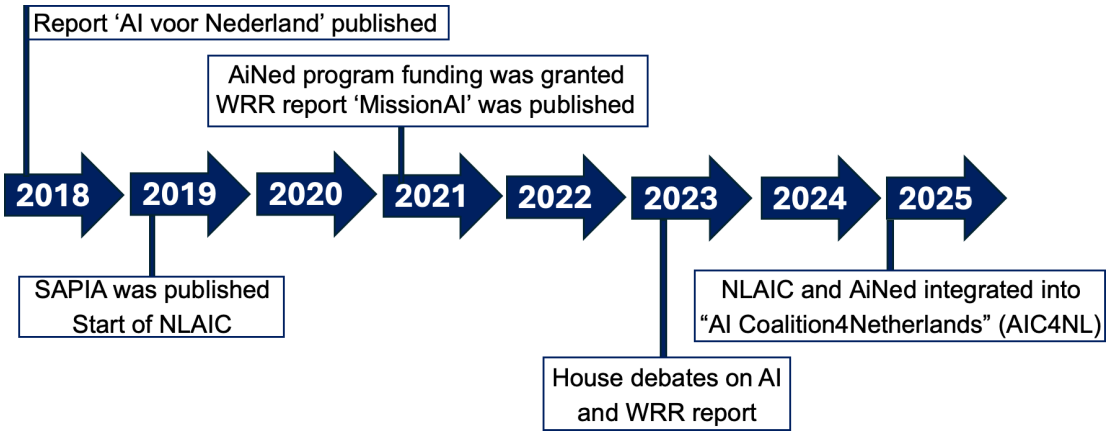



*FIGURE 1: Highlights in the development of the Dutch AI strategy.*

### 8.1.2 Fertile ground

The Netherlands enjoyed favorable initial conditions, which facilitated the emergence of the AI ecosystem. New technologies are more likely to emerge in regions where they align with the existing local capabilities. A patent analysis conducted by Xiai and Bosmand revealed that the technological relatedness of ICT to a region's existing knowledge base is an important predictor of the emergence of AI in that region. ICT provides the knowledge base and building blocks that equip the region with digital capabilities and infrastructures that support the local capabilities of capturing AI opportunities. Moreover, the diffusion of ICTs opens up new technological avenues for AI, thereby increasing the chances of regional technological diversification (*Xiai and Bosmand, 2021).* Over the past decade, the Dutch digital technology policies have matured and evolved, enabling the Netherlands to build up a strong ICT position, a well-developed digital infrastructure, as well as a digitally skilled population. A perfect starting point.

Before 2018, the Netherlands held a favorable position and was actively engaged in AI R&D but lacked a dedicated AI institute like the German DFKI (German Deutsches Forschungszentrum für Künstliche Intelligenz), established already in 1988. Still, in 2020 McKinsey concluded that the Netherlands was one of the nine European digital frontrunners (DF9) showing strong potential to take AI forward. The UK, Finland, Germany and Switzerland were in the top quartile (leading performance across most indicators); the Netherlands was, together with Sweden, Denmark, Norway and Luxembourg, in the 2nd quartile (strong performance across several indicators; Figure 2). "*The DF9's history of collaboration, based on their strong cultural and business ties, is a good fit for the concerted efforts required to develop AI applications. Together they have the potential to become Europe's AI locus, driving adoption, encouraging research, and maximizing the technology's impact. … The DF9 are all relatively advanced when it comes to AI readiness, a strong predictor of the ability to generate employment and growth. … The DF9's key strengths in terms of AI readiness include high levels of technology adoption potential, a solid digital and data infrastructure, and a supportive policy environment. If the DF9 adopt AI at scale, the potential economic impact could be as high as €42 billion annually (or 1.4 percent of GDP)"* (*McKinsey & Company, 2020*).

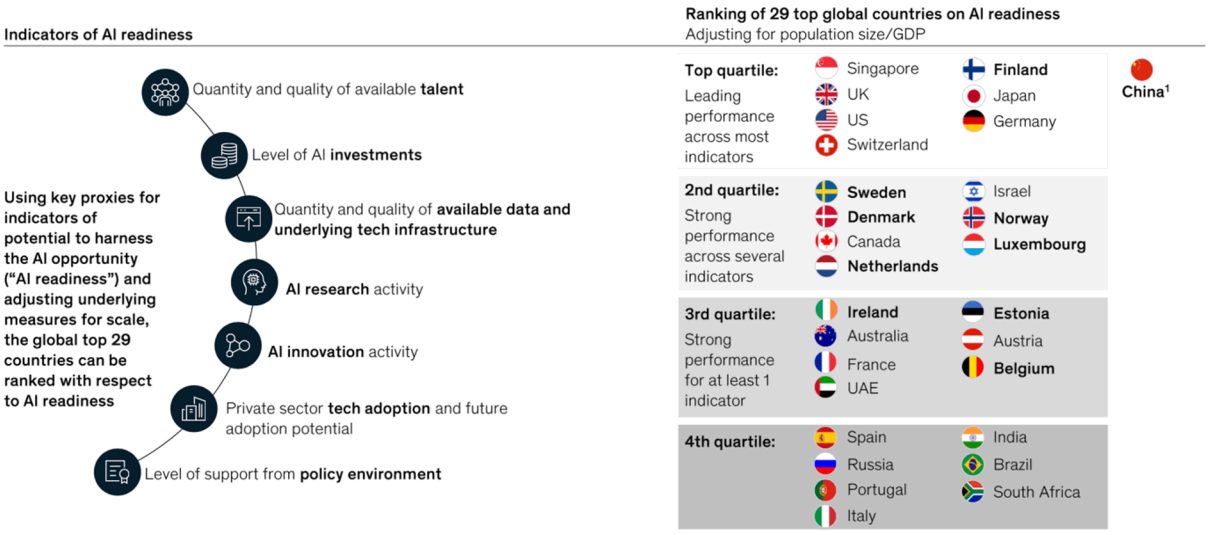



*FIGURE 2: DF9 are well positioned on AI readyness when accounting for size. DF9 countries in bold. Source: McKinsey & Company (2020).*

The existing strong cooperation between Dutch industry and universities is also an important building block. In the period 2012-2019, the USA had the highest involvement of companies in AI publications. Within the European Union, industry's role was significantly smaller. However, in the Netherlands, industry involvement was high. Industry publications often result from collaborations with higher education researchers. Figure 3 illustrates the share of AI publications in the period 2013-2019 that are the outcome of such cooperations. At that time, the Netherlands already had a high percentage of this type of cooperative research compared to other countries (*Rathenau Institute, 2021; Zhang, 2021*).

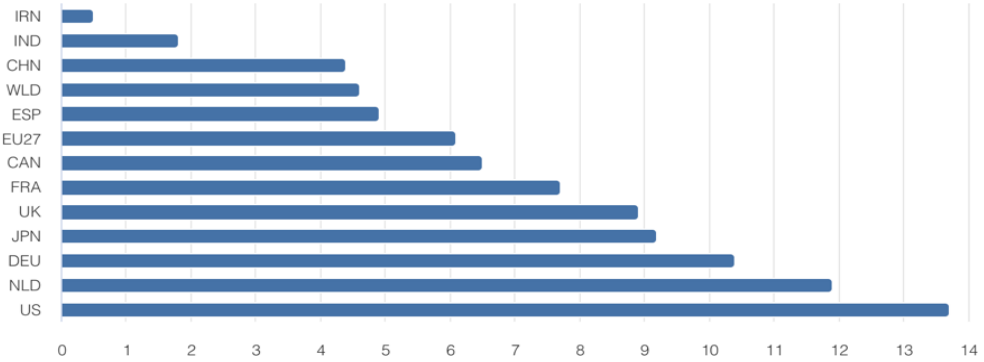



*FIGURE 3: Cooperation in AI publications between higher education institutes and industry (%) in the period 2013-2019 according to public data belonging to the AI index 2021. Sources: Rathenau Institute (2021), Zhang (2021)*

The '*Government AI Readiness Index*' by Oxford Insights evaluates how prepared governments are to integrate AI into the delivery of public services. For the 2024 Index, they assessed 188 countries and explored their readiness by examining 40 indicators across the pillars of Government, Technology sector, and Data & Infrastructure. Figure 4 illustrates the Netherlands' global standing in this index over the period 2017-2024. While there are some fluctuations, the Netherlands consistently ranks high in the Top 15. In 2024, the country held the 7th position (*Oxford Insights, 2024*).

Assessing the government's readiness for AI is important, but for policymakers also factors like R&D output, patents, investments in start-up companies, etc. are valuable. Stanford University's '*AI Vibrancy Index'* ranks 36 countries based on 42 indicators that, for example, evaluate research & development in terms of academic publications and citations, intellectual property generation, investments and start-ups, talent and skills. The previous negative trend appears to have stabilized and in 2022 and 2023 the Netherlands ranked 15th globally, with 7th position if only EU countries are considered (Figure 5; *Maslej, 2025; Stanford University, n.d.*).

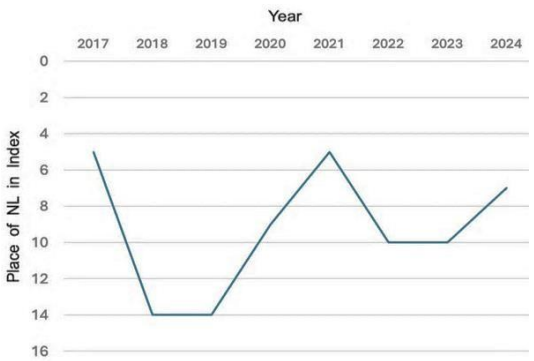



*FIGURE 4: Place of the Netherlands in the international benchmark 'AI Governmental Readiness Index' of Oxford Insights (2024).*

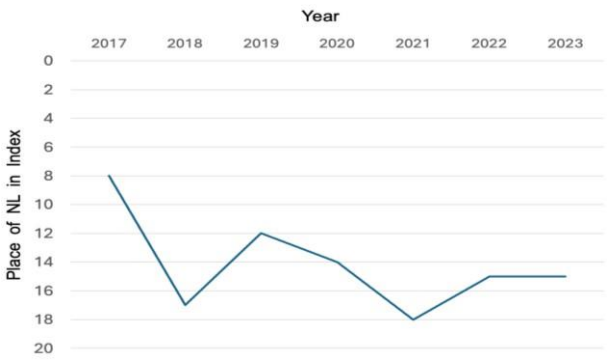



*FIGURE 5: Place of the Netherlands in the international benchmark 'Global AI Vibrancy ranking' of Stanford (Maslej, 2025)*

### 8.1.3 Use of existing coordination structures

Public authorities employ diverse instruments to foster research, development, and innovation in and with AI. These instruments encompass fiscal incentives, open calls for thematic research grants, strategic prioritization of policy concerns, and initiatives that promote public-private collaborations.

The programs and partnerships established under the Dutch national AI strategy are embedded into existing, broader structures that are not specifically focused on AI. For instance, the Dutch Research Council (NWO) coordinates public funding for academic research. Additionally, startups and scaleups can access venture and growth capital through the publicly funded private investment fund InvestNL. AI funding and investments often follow one of several routes through the numerous existing organizations, each with its unique focus.

However, given the existing innovation practices and policy instruments, the Netherlands opted for the best practices and instruments from the previous decade. For such a rapidly evolving domain as AI, which has its unique requirements, an adaptation to the new needs of the instruments might have been necessary. Consequently, it took a relatively long time to establish the AiNed research, development, and innovation investment program after the release of the national strategy report. From the initial proposal to the actual funding of projects through AiNed, more than three years were required. To address this gap between the 2019-2022 period, the Dutch government decided to provide kick-start funding of 23.5 million Euro *(Lazo et al, 2023*).

## 8.2 PUBLIC-PRIVATE-PARTNERSHIP AND STRATEGIC INVESTMENT PROGRAM

National PPPs are governed in various ways: some countries have more centralized platforms and manage all related projects through a single, centralized 'scheme'. Others have a stronger decentralized model and manage it through multiple agencies depending on the sector. According to the JRC report 'AI Watch – National strategies on AI: A European perspective', The Netherlands operates to a greater decree centralized through the NLAIC (see paragraph 6.2.1) and AiNed (see paragraph 6.2.2) (*Jorge Ricart et al, 2022*).

To some extent, this assertion holds true. However, the Dutch national AI strategy was not a singular, unified endeavor, but rather a collection of initiatives that either incorporate significant AI components or prioritize AI in their agendas. Due to the absence of a central, overarching management structure, there was potential overlap between the initiatives, and there was a risk that certain areas were insufficiently addressed. The Dutch government played a pivotal role in three documents: the Strategic Action Plan for Artificial Intelligence (SAPAI), the Netherlands AI Coalition (NLAIC), and the AiNed strategic investment program. We can consider the amalgamation of NLAIC and AiNed documents as the official national AI strategy. Simultaneously, other significant AI research and innovation efforts were underway. While multi-stakeholder initiatives such as ICAI (see paragraph 6.3.4) contributed to the Dutch AI landscape, at that time they lack the same comprehensive national scope. Later, these initiatives were integrated into the national AI strategy and their national coverage has also become much broader.

Stakeholder involvement is a key aspect of the Netherlands' AI strategy, which envisions an inclusive, quadruple helix collaboration involving academia, government, industry, and civil society. However, a 2022 report by TNO concluded that in practice, it remains challenging for all stakeholder groups to actively participate. "*Even though the NLAIC includes civil society and start-up representatives, they find it hard to participate*". The stakeholder involvement approach asked for the integration of various sectoral and regional interests, requiring a delicate balance between inclusion and the need to allocate investments effectively. The stakeholder involvement approach necessitated the integration of diverse sectoral and regional interests, requiring a delicate balance between inclusion and the imperative of allocating investments judiciously and effectively. While countries like Finland prioritized becoming an AI frontrunner and allocated the necessary resources to achieve this goal, the Netherlands initially focused on reaching consensus among stakeholders through its consensus-building 'polder-model'. This approach involved defining and refining policy approaches across ministries, creating a rather complex route to release funds through existing instruments to implement the strategy (*Lazo et al, 2023; Ailisto et al, 2023*).

As mentioned before, the two most important instruments to implement the Dutch AI Research & Innovation strategy are NLAIC (Netherlands AI Coalition) and AiNed, recently merged into the AIC4NL (AI Coalition 4 Netherlands).

### 8.2.1 Public-Private-Partnership Netherlands AI coalition (NLAIC)

The NLAIC, established in 2019 as one of the main building blocks of the Dutch AI strategy, aimed to organize the Dutch AI ecosystem. This 'quadruple helix' collaboration between government, industry, academia, and civil society sought to accelerate the development of AI and bring together individual AI initiatives from participating organizations. Initially, the NLAIC had 65 members; that number grew rapidly to over 450 members. NLAIC members agreed to build the necessary shared knowledge, expertise, and results across five building blocks which were considered to be crucial for driving innovative impact in diverse economic and societal application domains: (1) Human Capital, (2) Research & Innovation, (3) Data Sharing, (4) Human-centered AI / Societal Acceptance, and (5) Startups and Scale-ups.

Five overarching challenges were recognized:

- Innovation: accelerate the development of AI innovations in companies and government.
- Knowledge base: educate more specialists and students, currently in short supply.
- Employment market: educate and train/retrain employees.
- Society: make any uncertain socio-economic long-term effects of AI manageable.
- Data sharing: make more data available for machine learning.

The NLAIC has chosen to establish a single national AI network, functioning as a unified coherent entity. The NLAIC also established seven AI hubs across various Dutch regions (Figure 6). They play a crucial role in connecting and engaging local companies, knowledge institutions, and other organizations involved in AI research. By fostering these regional partnerships, the NLAIC aimed to accelerate technological advancements, foster innovation, promote social integration, and drive economic growth.

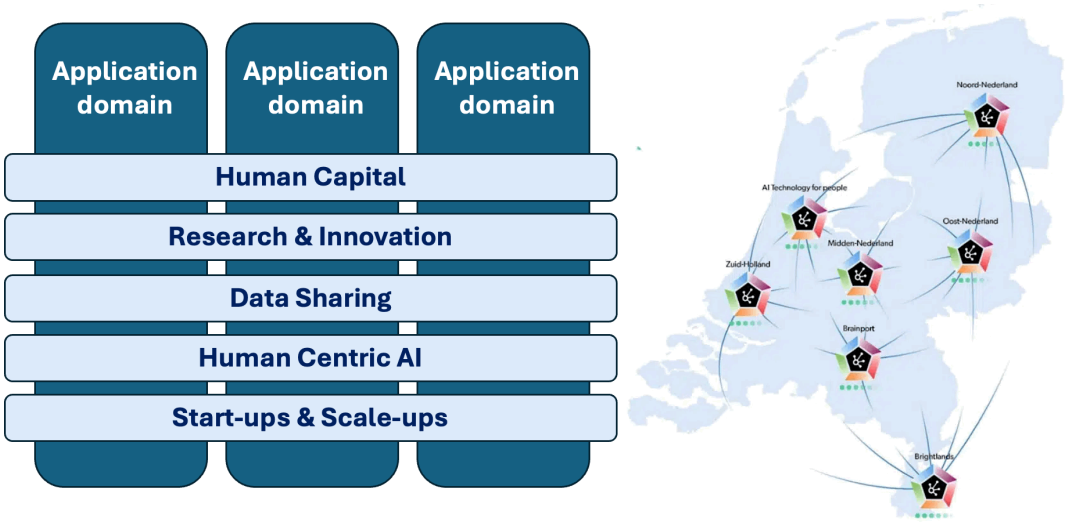



*FIGURE 6: Focus of the AI Hubs of the NLAIC / AIC4NL. The seven AI hubs of the NLAIC are essential in connecting and engaging local companies, knowledge institutions, and other organizations involved in AI*

Funding to initiate the NLAIC activities was provided by the Ministry of Economic Affairs, along with contributions from participating organizations. But a more extensive and structural funding source was needed to create real impact.

### 8.2.2 Strategic investment program AINED

The Netherlands has a strong base for knowledge development and innovations. To further strengthen that position, in 2020 the national government had established the 'National Growth Fund Investment Program' to invest in projects that maximize their contribution to sustainable and structural economic growth, create jobs, improve the quality of life, and strengthen the Dutch position on the world stage. Large national consortia could respond to calls-for-proposals.

The well-organized NLAIC community successfully submitted an application. The proposal received a funding of €205 million for its first period (2021-2027; *Rathenau Instituut, 2021*). This funding would be channeled through the AiNed foundation to individual projects to strengthen the Dutch economic position focusing on application, knowledge and innovation, people and skills, and collaboration (also with European organizations). Several existing governmental structures (earlier designed to serve specific purposes: fundamental research, applied research, entrepreneurship, and education) were used. Importantly, the selected projects were aligned with strategic national goals to ensure coherence, relevance, and long-term impact.

### 8.2.3 AI Coalition 4 Netherlands (AIC4NL)

The government played a crucial role in the development of the Dutch AI strategy, but its formulation and implementation required several years of coalition building and consensus-making. A report of TNO characterized the resulting Dutch AI strategy as a comprehensive array of AI policies, initiatives, and programs, with a central coordinating role for the Dutch government (*Lazo et al, 2023, 2024*). As a separate AI coalition ecosystem (NLAIC) and AI investment program (AiNed) led to confusion, fragmentation, and inefficiency, since January 2025 these two organizations have joint forces under the name "AI Coalition 4 Netherlands" (AIC4NL). That means: one mission, one strategy, one organization, one Board (*Jonker, 2025*).

In addition to mobilizing the ecosystem of strong partners from important economic and societal sectors, the AIC4NL also takes an integral role in program development and implementation. It is anticipated that this combination of ecosystem mobilization power and program execution capabilities will lead to a more widespread and rapid adoption of AI innovations. The AIC4NL can guide the entire AI development cycle, from fundamental research to testing applications in pilots and scaling up proven concepts, while ensuring that each step meets ethical and societal standards. The organization's close ties with governments at regional, national, and European levels enable it to effectively switch between policy and practice. Moreover, through its regional AI hubs (paragraph 6.3.1), the AIC4NL is firmly connected to regional AI communities, helping to address local challenges. The AiNed program employs various familiar instruments, including mobility grants and education vouchers. Additionally, it introduced several new instruments, such as ELSA Labs (see paragraph 6.3.2).

The new AIC4NL Agenda 2025-2027 (*AIC4NL, 2024*) outlines three key pillars:

- Increasing the number of active members, particularly those who use AI.
- Addressing societal issues: The Netherlands aims to be recognized as a leading country in responsible AI, with ethical guidelines being widely applied.
- Driving technological transformation through AI in sectors such as agriculture, defense and energy.

The AIC4NL toolbox includes:

- ELSA labs: focus on ethical and societal issues linked to AI.
- InnovationLabs: driving innovation.
- Creating solid AI infrastructure, such as High-Performance Computing, to enable large-scale AI applications.
- AI Parade and campaigns towards SMEs: increasing public and corporate involvement in responsible AI use.
- Learning Communities and Fellowship Grants: investing in talent development and AI skills.

## 8.3 IMPORTANT INSTRUMENTS

The set of tools to shape the Dutch AI ecosystem was quite diverse. As outlined above, a key step was organizing the national AI field, with the AI Coalition for Netherland (AI4NL) emerging as the central coordinating body. The Netherlands already has many generic (not AI-specific) innovation instruments. For example, the regional and national support organizations for start-ups and scale-ups such as Novel-T in Twente and the national TechLeap. AI-specific instruments were added to these generic innovation instruments. This chapter describes the main instruments to implement the Dutch AI Research and Innovation agenda.

### 8.3.1 AI Hubs

The implementation basis of AIC4NL is a single national AI network, operating as one coherent entity. The horizontal 'building blocks' of AIC4NL deal with topics of common interest; they are not application domain specific and as such, are best addressed in a national or international context.

Seven AI hubs in different regions of the Netherlands (Figure 6) bring together, connect and involve the regional business community, educational and knowledge institutions, governments and public organizations. Together, these AI-hubs form the national AI network and through a hubs-and-spokes model, the AIC4NL supports and stimulates collaborations in and between them (*NLAIC, 2022; AI4NL, n.d.).*

Each AI-hub focuses on specific application areas such as High tech & Smart industry / Energy & Sustainability / Mobility, Transport & Logistics / Life Sciences, Healthcare & MedTech / Media & Gaming / Healthy & Sustainable Food, Future Farming, AgriFood, Bio-circular / Circular Materials / Smart Digital Services / Port & Maritime / Security, Peace & Law.

### 8.3.2 ELSA Labs

AI can offer many advantages to industry, government and civil society organizations. At the same time, the use of AI raises a variety of ethical, legal, societal and economic questions (ELSE). In countries like China, Indonesia, and Thailand, strong majorities (77-83%) see AI products and services as more beneficial than harmful. In contrast, optimism remains far lower (36-40%) in places like the Netherlands, Canada, and the United States. In 2024, global

cooperation on AI governance intensified, with organizations including the OECD, EU, U.N., and African Union releasing frameworks focused on transparency, trustworthiness, and other core responsible AI principles. Globally, legislative mentions of AI rose 21% across 75 countries since 2023, marking a ninefold increase since 2016 (*Maslej, 2025*).

Through the ELSA Labs, AIC4NL is actively giving ELSE aspects a place, as the development of AI technology, social embedding, and capitalizing on economic opportunities must go hand-in-hand. The ELSE aspects and technology development are studied in conjunction, AI takes place based on public values and human rights, and frameworks and guidelines for the development of human-centered AI are tested and (re)developed. This is particularly relevant to application domains that are of strategic social and economic importance and key to the major transitions facing the Netherlands and Europe (*NWO, 2024; Georgieva, 2022*).

Moreover, ELSA Labs are virtual or physical environments within which knowledge, experiential practice, methods, techniques and tools are developed to facilitate human-centric Innovation in AI (*van Veenstra et al, 2021*). This entails configuring technological, ethical, legal and societal aspects with each other from the outset. ELSA Labs take the approach that parties from the quadruple helix (academic, government, industry, civil society) experiment together in a secure environment with concrete AI case studies. The central research questions originate from businesses and/or public organizations, with clear and relevant economic impact of the research in all cases. Focus is on research based on specific public and/or private cases in specific application areas.

> *"ELSA Labs are places where research into technological developments is carried out that incorporates ethical, societal and economic developments".*
>
> Cees Snoek, Scientific director Amsterdam ai

### 8.3.3 Innovation Labs

Successfully exploiting the potential of AI requires collaboration between public and private sectors. Innovation Labs are public-private partnerships dedicated to developing AI innovations, facilitating knowledge transfer, supporting business applications, and guiding ongoing knowledge development. Their objective is to rapidly develop AI knowledge from its fundamental stage to a stage of technology validation and demonstration in specific applications (e.g. Energy & Sustainability, Health & Care, Mobility, Transportation & Logistics, and Technical Industry).

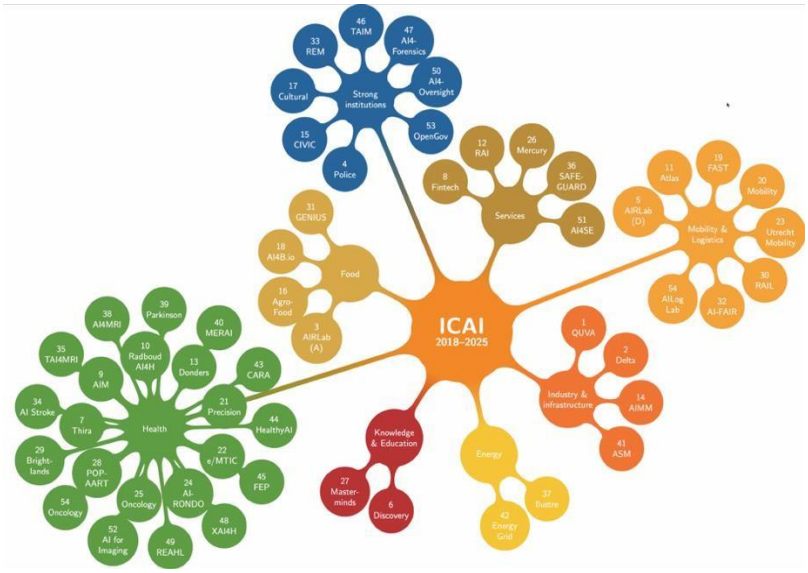
AI knowledge and experience from knowledge institutions and (deep) tech companies is brought together into concrete and usable AI techniques, models, tools and prototypes that meet the clear needs of participating companies. The focus is on innovative SMEs, startups and scale-ups within the aforementioned application areas, as well as, to relevant larger companies, knowledge institutions and civil society organizations (*NLAIC, n.d.*). The targeted Technology Readiness Level (TRL) is approximately 5-6.

### 8.3.4 ICAI Labs: Innovation Center for AI

AI experts are in high demand worldwide, and the Netherlands will have to be attractive to them to stay at the forefront in the field of AI. Talent attracts talent. Unfortunately, the Netherlands has seen declining net AI talent migration figures in recent years, suggesting that less AI talent has flowed into these countries (*Maslej, 2025*).

AI is profoundly transforming our society, making it crucial to establish and nurture a national AI knowledge and talent ecosystem. ICAI achieves this by developing and retaining talent, including students and researchers, for the Netherlands, while simultaneously attracting foreign talent to the country. ICAI is an open national collaboration initiative between knowledge institutions, industrial partners, and public organizations. Since its foundation in 2018, ICAI's mission is to keep the Netherlands at the forefront of knowledge and talent development in AI. ICAI does this through partnerships that foster collaboration in the development of AI technology, attracting, educating and retaining AI PhD students, as well as promoting open sharing of knowledge and technology (*ICAI, n.d.*). Founded by the University of Amsterdam and Vrije Universiteit Amsterdam, ICAI has its headquarters in Amsterdam and collaborates closely with international networks like ELLIS and CAIRNE. The ICAI organization receives financial support from various organizations, including the AIC4NL.

The AIC4NL also actively contribute to the development of ICAI's lab network. The organization has launched 54 labs in various cities across the Netherlands, each with its own areas of expertise that align with the strengths of that region. The ICAI Labs are established through collaborations with local forces, and they are primarily funded by their respective partners, which include knowledge institutes, industrial partners, governmental partners, EU and NWO funds, and other non-profit organizations. The ICAI Labs complement the Innovation Labs mentioned earlier. While the ICAI Labs engage in intensive collaboration with industry and business partners fund a significant portion of the research, they are primarily focused on AI research at a targeted TRL level of approximately 3-4.




Important ICAI instruments are (*ICAI, n.d.*):

- All *ICAI labs* are research collaborations between knowledge institutes and one or more industry, governmental or not-for-profit partners for impactful knowledge creation in AI.
- The public *ICAI Events* brings the ICAI community together to share knowledge, insights and experiences acquired in the labs and in other ICAI programs.
- *ICAI Experts* invest through joint appointments of academic staff, providing access for the next generation of AI talent to education, training and leading academics.

- *ICAI Launch pad* connects AI talent to the Dutch ecosystem by providing a matchmaking process between AI-PhD researchers and Dutch companies looking for AI talent.
- The *ICAI Venture* program stimulates and supports PhD researchers and staff of the knowledge institutes to look into the possibilities of starting a business with AI solutions.

### 8.3.5 Learning communities

As a systems technology, AI has a profound impact on various industries and the individuals who work in them. The field of AI is constantly evolving, with rapid advancements and market demands for new knowledge and well-trained employees and students. To address these challenges, the AIC4NL Learning Communities are multi-year collaborations that provide a hands-on approach for SMEs and civil society organizations to enhance their AI knowledge and skills. These communities foster collaborative learning opportunities with carriers of AI knowledge and skills, emphasizing joint learning through case studies (practice challenges).

The goal is to establish and maintain a high-quality and diverse pool of AI talent, comprising both employees and students. A Learning Community forms a knowledge e booster for AI, delivering scalable results and seamlessly integrating practical cases, particularly from SMEs, with knowledge building. This collaborative approach fosters increased AI knowledge and skills among employees and students, leading to the development of scalable learning modules. Companies, social organizations, and knowledge institutions, ranging from MBO to WO level, can participate in an AiNed Learning Community (*AIC4NL, n.d.; NLAIC, n.d.*).

### 8.3.6 European connections

Cooperation with other countries can strengthen AI research and innovation processes. In Europe, organizations such as Adra (AI-Data-Robotics Association), CAIRNE (Confederation of Laboratories for Artificial Intelligence Research in Europe), and ELLIS (European Laboratory for Learning and Intelligent Systems) take the lead, with short lines of communication with the AIC4NL, which has specific components in its program for this purpose. Two of the members of the Adra Board of Directors are from the Netherlands.

- ***XS Europe***
  An important aspect of a vibrant AI knowledge and innovation base is the interconnectedness of Dutch researchers globally, particularly within Europe. The XS Europe program of the Dutch Organization for Scientific Research NWO in collaboration with the AIC4NL, aims to support ideas and initiatives that address one or more challenges outlined in the national AI Research Agenda and are designed in collaboration with at least one foreign European collaborative partner organization. The proposed research should be groundbreaking while it is not certain in advance if the intended objective will be achieved. What matters is that every result, positive or negative, advances science. The assessment is based solely on the research proposal. The focus is on academic researchers. These projects strengthen the Dutch AI knowledge and innovation base, fostering international collaboration, particularly within Europe. XS Europe provides a platform to nurture promising ideas, innovative, and high-risk AI initiatives (*NLAIC, n.d.; NWO, n.d.*).

- ***EDIHs: European Digital Innovation Hubs***

SMEs must continuously invest in digitalization to ensure their future competitiveness and to remain relevant in the ever-evolving market. However, smaller companies often face challenges in making informed decisions, identifying suitable partners, and securing the necessary funding for these investments. European Digital Innovation Hubs (EDIHs) play a crucial role in the European Commission's strategy to provide comprehensive regional support and accelerate the digitization process (Figure 7; *European Commission, n.d. 5*).

EDIHs serve as regional hubs that assist SMEs in their digital transformation and enhance their digital maturity. They facilitate companies in articulating their demands, formulating action plans, and improving their access to expertise, support, and facilities within and outside the region. Entrepreneurs gain quick access to 'Test-before-Invest' facilities, knowledge institutions, and experts from their partner network. Additionally, EDIHs enable access to funding and insight into financial feasibility of digitization ambitions. EDIHs also address the need of SMEs for support in navigating the complex regional and European landscapes of sources of expertise and knowledge, facilities (such as field labs), and networks to support digitization. The European network of EDIHs promotes cooperation and ensures that SMEs can be referred to the most appropriate EDIH (European Commission, n.d. 5; n.d. 7).

In 2022, the Dutch government has selected 6 EDIHs: 5 focus on supporting digitization in business; they are located all over the country. The 6th EDIH focuses on digitization of public organizations. They receive funding from both the Dutch government and the EC. Each EDIH has his own technology and application domain specialization. In the upcoming next proposal phase, each EDIH 2.0 must focus much more on supporting SMEs to adopt AI and to refer them to relevant AI-actors. This creates overlap between activities of these EDIHs 2.0 and existing Dutch AI Hubs. Therefore, several regional AI Hubs are now discussing how to optimize their support to local SME's by joining forces with regional EDIH's.

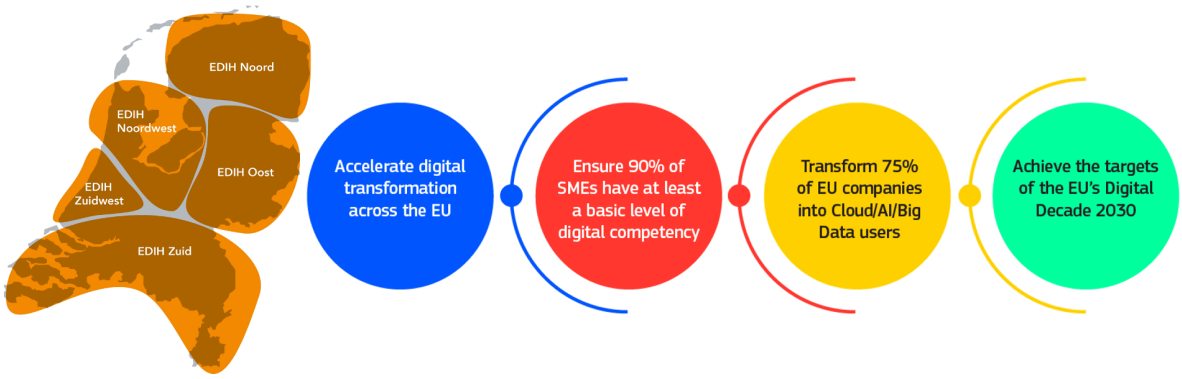



*FIGURE 7: European Digital Innovation Hubs (EDIHs) in the Netherlands.*
*Sources: Smart Industry (n.d.), European Commission (n.d. 5)*

- ***AI TEF: Test & Experimentation Facilities***
  The large-scale reference testing and experimentation facilities (TEFs) offer a combination of physical and virtual facilities, providing technology providers with comprehensive technical support to test their latest AI-based software and hardware technologies in real-world settings. TEFs primarily focus on testing mature AI–based technologies and solutions that have already been tested in the labs and now must be tested in real-world environments (*European Commission, n.d. 8*).

The previously mentioned EDIHs bring together local actors to support the digital transformation of their businesses and connect with other EDIHs across Europe. The main purpose of EDIHs is to “test-before-invest”; the technology is mature enough to be deployed. EDIHs also serve as the gateway to other European AI activities, such as the TEFs and AI Factories. TEFs are fewer in number compared to EDIHs. TEFs help technology providers to develop new technological solutions and bring them closer to the market in validating them in real environments. Technologies tested in TEFs have not yet reached the same level of maturity as those in EDIHs, as they still require substantial testing and validation in real environments before being deployed. The two instruments complement each other well.

There are TEF networks for four different application areas: Agri-Food, Smart Cities & Communities, Manufacturing, and Healthcare. The Netherlands is actively involved in two of these networks: AgrifoodTEF and TEF AI-Matters (manufacturing sector).

### 8.3.7 Start-ups and Sale-ups

Startups, scale-ups and SMEs are important drivers of economic growth, employment and innovation capacity. They renew the economy, invest in research, develop critical technologies, and often swiftly translate these advancements into novel innovative products and services. Moreover, they significantly contribute to accelerating the adoption of technologies within organizations (both public and private) and provide solutions to societal challenges.

For start-ups, main hurdles could be bureaucracy, (lack of) speed of action, and competition. Numerous initiatives exist in the regions, all of which support AI-driven startups and scale-ups. These initiatives encompass a wide range of services, including early-stage funding, intellectual property advisors, coaches and mentors, as well as accommodation to research and testing facilities. In fact, the sheer number of initiatives can sometimes make it challenging for young businesses to find the right partners. AI start-ups can use the generic support provided by start-up incubators, but their specific needs often differ from those of regular start-ups.

AI start-ups often face higher start-up costs, making them more capital-intensive. This is partly due to the challenge of obtaining the necessary data. Structuring databases to be ‘data ready’ is time-consuming, and training models is also time-consuming. Additionally, the costs associated with server and cloud infrastructure are substantial. Furthermore, the knowledge gap with the potential customer group is perceived as greater, leading to longer sales processes.

In response to these challenges, several AI-hubs in Dutch regions have developed AI-specific support systems. For instance, the AI-hub Brainport offers comprehensive support to AI entrepreneurs, serving as a one-stop-shop that provides generic and AI-specific support instruments and guidance throughout the journey from idea to market.

In addition, there are some important national programs.

- ***Breaking barriers (AIC4NL)***
  The “Breaking Barriers” program of the AIC4NL the path from regional start-up through national professionalization, to European scale-up for AI scale-ups is streamlined. AI companies ready to scale up can receive a thorough business assessment. After this, they can receive targeted customized support for the scaling-up challenges they face. The program mobilizes generic scale-up expertise from its partners such as TechLeap and

complements it with AI-specific support such as access to data and infrastructure, AI legislation and state-of-the-art AI developments and applications (*AIC4NL, n.d*.).

- ***Techleap (Dutch government)***
  Techleap, a data-driven ecosystem builder with a founder-centric approach, collaborates with the Dutch government to achieve economic and societal impact. As a non-profit organization funded by the Ministry of Economic Affairs, Techleap quantifies and accelerates the Dutch tech ecosystem. Their mission is 'to transform the Dutch tech landscape into an ecosystem where innovation thrives'. To achieve this, Techleap connects and empowers Dutch tech founders and CXOs, hosts events, creates and shares resources, works with VCs and LPs, collaborates with the government on startup policy, and makes connections to help startups grow. The State of Dutch Tech is an annual report that is published by Techleap and shared with key stakeholders. It is a catalyst for change in the Dutch Tech Ecosystem where it's necessary. With a data-driven strategy, the report highlights the current State of the Dutch Tech ecosystem through themes like startups and scaleups, policy, diversity and capital (*Techleap, n.d*.).

> *"Tech innovation is crucial for ensuring economic security, geopolitical autonomy for future generations and plays a key part in solving pressing global problems".*
>
> Constantijn van Oranje, Special Envoy at Techleap

Techleap runs three kinds of programs:

- Growth programs: (1) RISE for early-stage scale-up founders, (2) SHINE for late stage scale-ups, and (3) Pole Position for early-stage deeptech founders.
- Founder Communities for scaleup founders and their leadership teams.
- Knowledge Hub: All the insights and latest news about the Dutch tech ecosystem in one place.

## 8.4 CONCLUSION

The Strategic Action Plan for Artificial Intelligence (SAPAI) marked the beginning of the Netherlands' first AI Research and Innovation policy. The resulting Public-Private-Partnership 'Dutch AI Coalition' (NLAIC) and the strategic AI investment program AiNed, which are now combined into the 'AI Coalition 4 Netherlands' (AIC4NL), are the cornerstones of the Dutch approach.

The Dutch government played a pivotal role in developing and central coordinating this strategy. However, the process of shaping and implementing it involved a lengthy period of several years, encompassing coalition building and agreeing on a strategy. Achieving a coherent balance between the priorities and interests of all stakeholders across various sectors and regions was a significant challenge. This Dutch approach, often referred to as 'poldering' (consensus-building), is undoubtedly less agile compared to more top-down models used in several other countries. The Dutch government chose a generic approach and utilized existing instruments to make funding for the national AI research and innovation plan available. This approach necessitated a

collective proposal from many different stakeholders. One of the key challenges was to bring together that diverse group of stakeholders, including industry, academia, government, and civil society, each representing distinct interests and working styles. Another challenge was to maintain focus and coherence within the proposal, ensuring it aligned with the overarching national AI strategy and its goals.

The Netherlands is well-aligned with the European Union's aspirations and values regarding AI. EU legislation and policies, such as the AI Act and the Digital Europe program, significantly influence the Netherlands' strategy in AI development. In the Netherlands, ELSE (ethical, legal, social acceptance, economic) aspects play an important role in AI research and technology development. Research and technology advancements can lead to significant scientific and technological impacts, which can have economic impacts when they align with business challenges. However, the success of these economic impacts depends on the widespread societal acceptance of the AI technologies used. The Netherlands recognizes the crucial role of these preconditions in determining the economic and social impact of AI.

The Netherlands is also actively pursuing international collaborations in AI research and innovation. The country is well-connected to relevant European networks such as Adra (AI-Data-Robotics Association), ELLIS (European Laboratory for Learning and Intelligent Systems), and CAIRNE (Confederation of Laboratories for Artificial Intelligence Research in Europe). Valuable collaboration partners can also become competitors. For instance, competition for scarce AI talent was discussed during several meetings. In the Netherlands, the prevailing thought is that cooperation is essential at the European level, and several national programs encourage this approach.

There's no standard model for a national AI strategy that can be applied universally across all countries. However, countries share certain practices and challenges, and they can learn from and be inspired by each other's approaches. Regardless of the national context, developing and maintaining a national AI strategy is an ongoing process of learning, reflection, and making necessary adjustments to approaches, choices, and tools. Hopefully this study will contribute to that.

# 9. NATIONAL AI STRATEGY FINLAND

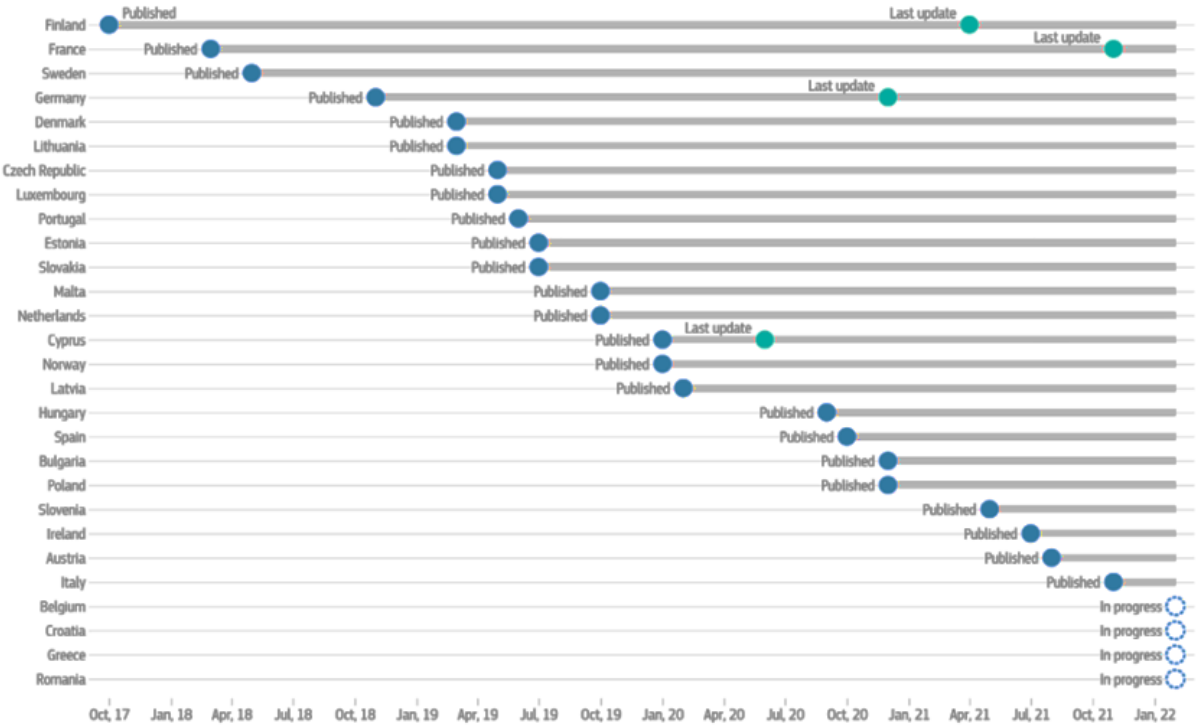
Authors: Anne Bergen, Iddo Bante
Adra-e WP4 T4.4 contribution
Date: 2025-05-15

## 9.1 GOVERNMENT INITIATE NATIONAL AI PROGRAMS

The potential economic and societal impact AI drew policymakers' attention in Finland, leading the country to become one of the first European member states to launch a national AI strategy. This strategy plan commenced with the publication of two interim reports in 2017 and 2018, followed by the final report in 2019. The strategy underwent further refinement and updates in 2020.

### 9.1.1 Finland's Age of Artificial Intelligence

In 2017, the Finnish Ministry of Economic Affairs and Employment published its first national AI strategy report, entitled "***Finland's Age of Artificial Intelligence***" (FIGURE 1; *Finnish Ministry of Economic Affairs and Employment, 2017; Jorge Ricart, 2022; European Commission, n.d. 11)*. The report assessed Finland's AI strengths and weaknesses, offering recommendations to propel Finland into a leading country in the development and application of AI. It described the important to ensure that companies receive adequate support for the research and development of AI-based innovations, to facilitate the re-use of public data, and to prepare the Finnish society for the changes the AI age will bring. The report brought AI to the attention of decision-makers across both the public and private sectors (*Ailisto et al, 2023; NordForsk, 2024; HolonIQ, 2020*).




*Source:* JRC – European Commission
Note: Last update of the table on 1 February 2022. The information in the table is based on input from national contact points or public sources. It presents release dates of national AI strategies in their native language. In addition to EU Member States, this table also includes Norway as Associated Country highlighted with the superscript [AC]. Switzerland does not intend to release a national AI strategy.

*FIGURE 1: Overview of national AI strategies in the EU Member States. Finland was one of the first European Member States launching a national AI strategy. Source: Jorge Ricart et al (2022).*

### 9.1.2 Work in the Age of Artificial Intelligence

In 2018, the national AI strategy was further expanded with the publication of a second interim report titled "***Work in the Age of Artificial Intelligence***" (*Finnish Ministry of Economic Affairs and Employment, 2018*). While the first report primarily focused on deploying AI in business and the public sector, this second report addressed concerns about widespread unemployment caused by AI. It emphasized the importance of ensuring employment and explored the impact of AI on the labor market and the transformation of working life. The report presented policy recommendations related to the future of work, including growth and employment, the labor market, skills requirements and learning, and ethics. The report discussed topics such as dedicated new AI-powered education and vocational education and training; reform of the lifelong learning system by integrating AI skills; and support for labor mobility. The report's primary impact was through its recommendations and the subsequent public discussion it sparked (*Ailisto et al., 2023; NordForsk, 2024*).

### 9.1.3 Leading the way into the Age of Artificial Intelligence

In 2019 the Finnish Ministry of Economic Affairs published the final report of Finland's AI Program, entitled "***Leading the way into the age of artificial intelligence"*** (*Finnish Ministry of Economic Affairs and Employment, 2019*). The report presented eleven recommendations and a list of actions taken. The approach "*emphasizes business competitiveness through efficient data use, rapid AI adoption, and developing top-tier expertise. The strategy also stresses AI's role in public services and security preparedness, aiming to establish Finland as an AI leader. This strategy balances technological innovation with ethical considerations, aiming to leverage AI for economic growth and societal advancement*" (*NordForsk, 2024*). Several of the actions were quite concrete. The report presented investment figures for several key policies. For example, the AI Business Program had been allocated EUR 100 million over a four-year period. Additionally, the Finnish Centre for Artificial Intelligence (FCAI) received EUR 8.3 million in flagship funding for the years 2019–2022.

The first Finnish AI strategy program prioritized national competitiveness and rapid adoption of AI technologies in industry on one hand, while also expressing concern for the employment situation on the other. After the 2019 election, the new coalition cabinet adopted a different perspective on AI. According to *Ailisto et al (2023*), "*the government program mentions 'AI' eight times, of which six refer to the threats and ethical concerns related to AI and the need to regulate AI to prevent hazards, one relates to using AI as a tool for applying social benefits and one is about the need for taxation changes due to AI enabled automation. AI as an enabler for increased productivity, business or competitiveness is lacking from the program. In practice, however, the differences of the government policies are not as dramatic as the programs would indicate*." In 2020, the Finnish AI strategy underwent an update, leading to concerns among some individuals that the program appeared to have begun anew, lacking a clear and cohesive trajectory.

### 9.1.4 Artificial Intelligence 4.0 Programma – Finland as a leader in twin transition

In the new AI strategy plan, initiated by the Ministry of Economic Affairs and Employment, two important developments were combined: AI and Industry 4.0. Goal was to speed up the

introduction of AI and to promote the fourth industrial revolution. The first interim report in 2020 ‘Artificial Intelligence 4.0 - Start-up phase to the implementation phase’ (*Finnish Ministry of Economic Affairs and Employment of Finland, 2020*) was followed by a second interim report in 2021 ‘Artificial Intelligence 4.0 - Finland the winner in a double transition - from ambition to practice’. In 2022 the final updated AI strategy plan was published: ‘Artificial Intelligence 4.0 programme - Finland as a leader in twin transition’ (*Finnish Ministry of Economic Affairs and Employment of Finland, 2021, 2022*).

In these reports, the Finnish position is presented, and a vision for Finland 2030 is articulated. The final report underscores the double green and digital transitions and sets three primary objectives: bolstering high-level research, development, and investment in key technologies; augmenting the adoption of digital capabilities and technologies that catalyze this dual transition; and making Finland a pioneer and international leader in AI and the twin transition. A particular emphasis is placed on involving SMEs in AI development and adoption. AI is recognized as a pivotal technology, and in this report, it is combined with a diverse range of other cutting-edge digital technologies, such as robotics, quantum computing, high-performance computing, and the Internet of Things, to facilitate industrial transformation and accelerate the twin transition of Finland’s economy by 2030 (*Ailisto et al., 2023; NordForsk, 2024; European Commission, n.d. 6*).

## 9.2 SOME SIGNIFICANT NATIONAL AI ACTIVITIES

### 9.2.1 Resarch Council of Finland

The Research Council of Finland (until August 2023 Academy of Finland) has allocated an estimated 315 million Euros from 2018 to 2022 for AI research and its application areas. This funding also includes grants from the Strategic Research Council and support of flagships and research infrastructures strengthening the ecosystem on AI research. A significant portion of the funding is project-based, while career instruments are used to enhance the skills and competences in AI research and application domains. In collaboration, the Research Council of Finland and Business Finland implemented the ICT 2023 research, development, and innovation program, which spanned the years 2014 to 2023. Its objective was to augment Finland's scientific expertise in computer science and foster the widespread adoption of ICT. Each year, AI research can be incorporated into research proposals; however, AI was specifically mentioned in the calls in 2017 and 2021 (*Ailisto, 2023; NordForsk, 2024*).

### 9.2.2 National Flagship program - Finnish Center for AI (FCAI)

The Finnish Center for AI (FCAI), a consortium comprising VTT, Aalto University, and the University of Helsinki, is one of the ten flagship programs of the Academy of Finland. The FCAI's overall budget estimate, which spans from 2019 to 2026, is 360 million Euros. This budget encompasses the total sum of projects and resources utilized by the FCAI partners in AI research and development during this eight-year period and comes from various sources (a.o. Research Council of Finland, EU, Business Finland, private companies). In 2024, the FCAI flagship 'Finnish Doctoral Program Network in AI' was granted 100 new doctoral positions (25.5 million Euro) from the Ministry of Education and Culture. FCAI collaborates with companies, organizations, and societies interested in AI. This interest may include cutting-edge research, knowledge exchange, knowledge transfer, and personnel education. FCAI also fosters student collaboration and recruitment of young talents (*Ailosto, 2023; NordForsk, 2024*).

### 9.2.3 ELLIS Institute Finland

ELLIS (European Laboratory for Learning and Intelligent Systems) is a pan-European AI network of excellence. The FCAI has hosted the 'ELLIS Unit Helsinki' for many years. In 2024, the FCAI announced the expansion of this local node into the national 'ELLIS Institute Finland', marking a significant step for the ELLIS network in Northern Europe. Funding is coming from both the Ministry of Education and Culture and the industry. This new institute aims to drive breakthroughs in AI and machine learning, leveraging Finland's advanced AI ecosystem. See paragraph 7.4 (ELLIS, 2024; FCAI, 2024).

### 9.2.4 Nordic Artificial Intelligence Collaboration (NAIC)

AI has a profound impact on all sectors of society and is rapidly evolving. However, Nordic countries' adoption and investments in AI technologies failed to keep pace with international development trends and competitors in recent years. As per the Global AI index 2024 (Tortoise, 2025), which grades 83 countries, Finland's position declined from 10th in 2023 to 15th in 2024. Developing sound and informed responses requires knowledge sharing and capacity and competence building among research and innovation communities. Collaborating Nordic countries can swiftly and flexibly address their shared priorities and needs.

In 2024, the Nordic countries embarked on an ambitious project to establish a cross-border joint AI research and innovation center. This center aims to foster responsible and ethical AI use to enhance security and boost business competitiveness. The NAIC project will expand collaboration in key technology areas, including AI, cybersecurity, and digitization. NAIC is funded by all five Nordic states, including Iceland. NAIC's mission is to enhance Nordic cooperation in the AI domain to drive international competitiveness and prevent the region from falling behind global leaders in terms of AI technology adoption. Regional research and innovation cooperation, along with the sharing of best practices, is important to address both the immense opportunities and the technical and ethical challenges posed by AI. By working together, NAIC can effectively tackle the challenges faced by the Nordic countries. A unified Nordic AI strategy, which integrates resources, expertise, and innovative capabilities, enables the efficient development of robust and ethically sound AI systems and services (*NordForsk, 2024; ComputerWeekly, 2024*).

### 9.2.5 First AI Accelerator (FAIA)

Finland's first AI strategy document proposed FAIA, which was established relatively quickly. Funding was limited to 2018–2021. The accelerator FAIA was initiated as a joint venture by the Ministry of Economic Affairs, Technology Industries of Finland and Silo.AI. FAIA aimed to help companies bring AI experiments into production and accelerate the adoption and deployment of AI in enterprises. Selected high-potential startups were prepared for strategic partnerships or acquisitions. FAIA conducted accelerator programs and produced reports like the AI Landscape and State of AI in Finland (*FCAI, n.d.; FAIA, n.d.; Ailisto, 2023*).

### 9.2.6 AI for Business program, Business Finland

The AI Business program, which ran from 2018 to 2021 and had a budget exceeding 200 million Euros, aimed to position Finland as a leading destination for AI research & development, and to boost Finland's international digital service business by establishing a modern B2B platform economy that leverages AI to generate new value from data. The program was designed for Finnish startups, SMEs, midcaps, and large companies, as well as research organizations. Companies could apply for funding for their own development projects or joint project with other companies and research organizations. The program's objectives encompassed several key areas: enhancing the competitiveness and productivity of Finnish companies through innovative AI and platform economy-based solutions; strengthening expertise in these fields; improving the productivity of the public sector by acquiring new AI and platform solutions; establishing digital private-public platforms to catalyze new innovations; encouraging the adoption of AI and platform economy-based innovations; and building competitive global ecosystems that make Finland an attractive investment destination (*Business Finland, n.d.*).

### 9.2.7 Aurora AI

The cross-governmental program Aurora, which ran from 2018 to 2022, aimed to facilitate the development of AI-based, well-targeted personalized digital services that catered to citizens at the opportune moments in various life situations and events. The goal of this national AI program was to prepare the country for a human-centric and ethically sound society in the era of AI, thereby fulfilling the needs of citizens, public administration, and industry (*European Commission, n.d. 11*).

## 9.3 EU PROGRAMMES AND INITIATIVES

Finland actively participates in AI-related projects of Digital Europe and Horizon Europe, the European Union's framework program for research and innovation. This is not just about conducting research and innovation. Finland also participates actively in various intergovernmental organizations and Public-Private-Partnership networks.

### 9.3.1 Most relevant European ecosystems and partnerships

The ***AI-Data-Robotics Association (Adra)*** was established in 2021 by five European organizations: BDVA, CAIRNE, ELLIS, EurAI, and euRobotics. Adra serves as the private site of the European AI-Data-Robotics (ADR) Partnership, one of the European Partnerships in Cluster 4 (digital, industry, and space) within Horizon Europe. The Partnership was officially launched on June 23, 2021, building upon the work of the prior Horizon 2020 Partnerships SPARC PPP (euRobotics) and Big Data Value PPP (BDVA), as well as the broader European AI community. Seppo Tikkanen of DIMECC Oy (Finland) and Petri Myllymäki, director of the Helsinki Institute for Information Technology and vice director of the Finnish Center for AI, are members of the Board of Directors.

The Partnership is the European focal point for ADR technologies, serving as an entry point for organizations seeking collaboration and direct engagement with the European Commission in shaping the direction of these three technologies and their application domains. Adra is focusing on fostering European leadership in ADR technologies with a significant environmental, social, and economic impact. The Partnership drives innovation, promotes acceptance and uptake of these technologies, and boosts new markets, applications, and attracts investment, to create technical, economic, and societal value for businesses, citizens, and the environment (*Adra, n.d.*). In 2022, Adra played a crucial role in the launch of the ***Adra-ecosystem (Adra-e)***. This European Coordination and Support Action (CSA) is designed to ensure the success of the ADR Partnership by providing support for Adra's activities.

The ***Big Data Value Association*** (***BDVA;*** the legal name is Data, AI and Robotics DAIRO aisbl), one of the founding organizations of Adra, is an "*industry-driven international not–for-profit research and innovation organization with a mission to develop an innovation ecosystem that enables the data-driven and AI-enabled digital transformation of the economy and society in Europe*" (*BDVA, n.d.*). The BDVA was established in 2014 as the private counterpart of the European Commission in the Big Data Value Public Private Partnership. Currently, BDVA comprises over 240 members across Europe, representing a diverse range of industries, including large, small, and medium-sized enterprises, as well as research and user organizations. Tuomo Tuikka of VTT Finland is member of the Board of directors (*BDVA, n.d.; FCAI, n.d.*).

***ELLIS***, the ***European Laboratory for Learning and Intelligent Systems***, is a pan-European AI network of excellence that focuses on fundamental science, technical innovation, and societal impact. Established in 2018, ELLIS has rapidly grown into a network comprising 41 ELLIS units and one associate unit at world-renowned institutions across 17 countries, 16 ELLIS research programs and a pan-European PhD program. ELLIS builds upon machine learning as the driver for modern AI and aims to secure Europe's sovereignty and international leadership of

AI-made-in-Europe by connecting top researchers and by creating multi-centric AI research laboratory. ELLIS's primary objective is to ensure that the highest level of AI research is conducted in open societies within Europe. ELLIS was one of the founding organizations of Adra.

For many years, the Finnish Center for Artificial Intelligence (FCAI) has been hosting the local node ELLIS Unit Helsinki. In 2024, it was announced that this local node would be expanded into the second ELLIS institute; the first ELLIS Institute was established in Germany in 2023. This new national 'ELLIS Institute Finland' represents a significant expansion of the ELLIS network in Northern Europe. The Finnish Ministry of Education and Culture has committed 10 million Euros per year (from 2025 to 2028), along with a 6 million Euro for the launch phase. Additionally, the foundation of Peter Sarlin, CEO and co-founder of Silo AI, has contributed 10 million Euros towards ELLIS professorships. This new institute aims to drive breakthroughs in AI and machine learning, leveraging Finland's advanced AI ecosystem and home to Europe's fastest supercomputer, LUMI (*ELLIS, 2024; ELLIS, n.d.; FCAI, 2024*).

The ***Confederation of Laboratories for Artificial Intelligence in Europe (CAIRNE***), formerly known as CLAIRE, is an initiative by the European AI community that has established a collaborative European network of Centers of Excellence in AI. CAIRNE's mission is to ensure that European AI research and innovation align with ethical principles, sustainability, and societal well-being. To achieve this, CAIRNE fosters collaboration between research institutions, industry, and policymakers to build an AI ecosystem that empowers European talent, reduces dependence on non-European technology, and drives human-centered, trustworthy, and responsible AI innovation. CAIRNE is lobbying for the establishment of a large-scale CAIRNE Hub, a new AI facility with state-of-the-art 'CERN-like' infrastructure and ambitious goals. The Hub will be an environment where Europe's brightest minds in AI can meet and work together for limited periods, thereby enhancing the flow of knowledge among European researchers. CAIRNE is one of the founding organizations of Adra (*FCAI, n.d.; CAIRNE, n.d.*).

The ***European Association for Artificial Intelligence (EurAI***), formerly known as ECCAI, was established in 1982 to serve as a representative body for the European AI community. Its primary objective is to promote the study, research, and application of AI across Europe. Beyond its academic pursuits, EurAI actively engages with policymakers and European stakeholders to address the societal impacts of AI and promote ethical guidelines for its development. EurAI is a founding member of Adra. The Association is composed of national society members who possess independent legal status. These members are scientific European associations dedicated to AI; in Finland the Finnish Artificial Intelligence Society FAIS (*EurAI, n.d.; FCAI, n.d.*).

### 9.3.2 European Digital Innovation Hubs (EDIHs)

The Digital Europe program includes several programs designed for SMEs to bridge the gap between research and the market or society. One of its instruments is European Digital Innovation Hubs (EDIH). These hubs provide SMEs with the necessary digital competencies to enhance innovation, accelerate time-to-market, and support finding investments and external funding. EDIH also offer access to test-before-invest facilities, relevant innovation networks and ecosystems, and competence development. The EDIH Catalogue (*European Commission, n.d., 7*) mentions nine EDIHs in Finland, of which four are funded by the EC. These four are:

1. *Finnish AI Region EDIH (FAIR):*
   The technological focus is on AI, but they also offer expertise in, for example, cybersecurity, high-performance computing, and extended reality.
2. *HealthHub Finland (HHFIN):*
   The application focus is on healthcare, but next to more health-related technologies, they also mention AI, Big Data, and high-performance computing as technologies they support SMEs with.
3. *Location Innovation Hub (LIH):*
   This LIH center of excellence in location information, coordinated by the Finnish Geospatial Research Institute, mentions Big Data, AI, and HPC as important technologies.
4. *Robocoast EDIH:*
   This EDIH supports the manufacturing industry with the use of digital technologies to stimulate sustainable growth and competitiveness. It's clear that technologies such as AI, Big Data, HPC, and IoT are important for these Industry 4.0 activities.

It's clear that AI also plays an important role in all five others Finnish EDIHs which do not receive funding from the EC but from other sources.

5. *Finnish Center for AI (FCAI):*
   FCAI is a nationwide competence center for AI in Finland. It implements Finland's national AI strategy and action plan. Its mission is to create Real AI for Real People in the Real World.
6. *Arctic Development Environments Cluster:*
   The cluster has 50 infra environments and laboratories and more than 750 experts and specialists. The themes include, e.g. product testing and analysis, IoT, VR/AR, cloud services, and big data.
7. *Arctic Drone Labs:*
   The EDIH is active in the field of UAS, robotics, autonomous systems, and associated fields.
8. *DigiCenterNS:*
   The focus areas are digitalization, ICT in manufacturing, energy technology, and digital transformation in the health industry.
9. *OuluHealth EDIH:*
   Focus is on the healthcare application domain.

### 9.3.3 Testing and Experimentation Facilities for AI (TEF)

Testing and Experimentation Facilities (TEF) for AI are another instrument of the Digital Europe program. To facilitate the transition from research lab to market and to stimulate AI uptake, the European Union, in collaboration with its member states, co-funds these facilities. These specialized large-scale reference sites are designed to test and experiment with state-of-the-art AI and robotics solutions. TEFs offer a combination of physical and virtual facilities, primarily providing technical support to innovators. This support enables them to test their latest AI-based software and hardware technologies at scale in real-world environments (Technology Readiness Levels 6-8). This includes support for full integration, testing and experimentation of the latest mature AI-based technologies already tested in the lab (*European Commission, n.d. 8; CitCom, n.d*.).

Finland participates in three of the five TEF networks: TEF Health, CitCom.aiTEF, and PREVAIL TEF.

- TEF Health focuses on the healthcare sector, from next-generation artificial hearts to, for example, the use of machine learning in medical imaging and diagnostics.
- The CitCom.aiTEF tests AI and robotics before they get into places where humans live and move around. From self-driving cars, telecommunications data retrieval software, to the robotic tractor used in a municipal park.
- AgrifoodTEF deals with the agricultural sector and food production.
- AI-Matters TEF tests technology within manufacturing.
- PREVAIL TEF focuses on the design of future edge AI hardware and chips for AI, drawing requirements from the four above-mentioned domain-specific TEFs.

## 9.4 PATENTS

The number of patent applications per capita is an indication how innovative a country is, given its population size. Figure 2 shows that South Korea and Luxembourg hold the distinction of having the highest number of granted AI patents per 100,000 inhabitants (resp. 15 and 13). China, the USA, and Japan follow with 5-6 patents. Finland, with just under 1 patent per 100,000 inhabitants, belongs to the next group. When examining the change in granted AI patents per capita from 2013 to 2023, Luxembourg, China, and Sweden experienced the most significant increase, but also Finland saw a nice increase in the number of patents granted per Finnish resident during this period (*Maslej et al, 2025*).

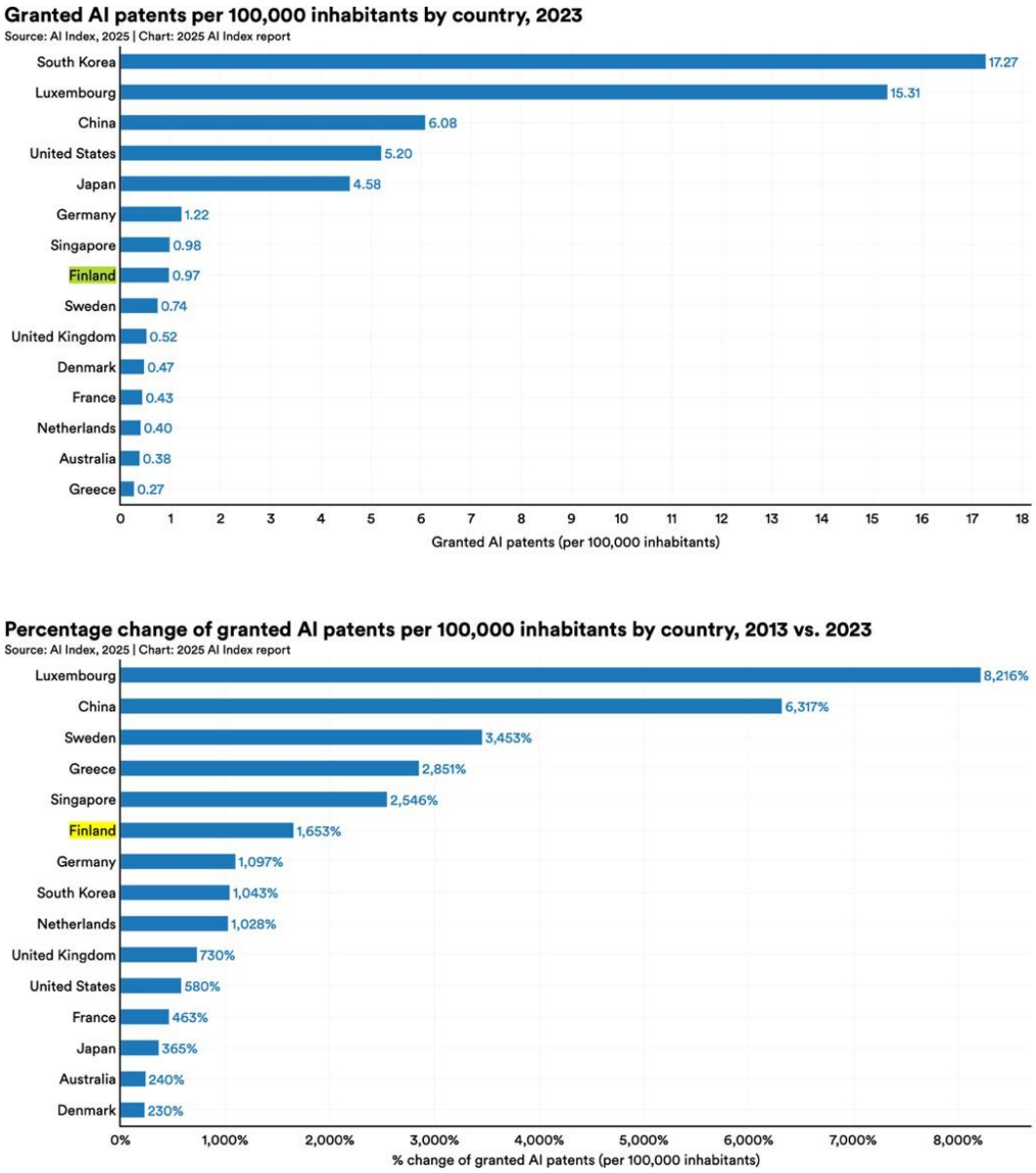



*FIGURE 2: Number of granted AI patents per 100,000 inhabitants per country in 2023. Source: (Maslej et al, 2025).*

# 10. CONCLUSIONS AND OUTCOMES

A literature study and over 17 interviews and in-depth discussions with stakeholders from exemplary ADR ecosystems were conducted to explore European AI-Data-Robotics (ADR) innovation approaches and regional and national best practices.

To facilitate dialogue among stakeholders in the ADR ecosystem and enhance collaborative knowledge about regional and national innovation strategies, as well as the added value of national and European instruments in stimulating ADR adoption, over 17 interactive workshops and presentations were organized during various events hosted by key players in the ADR community, including Adra (ADRf, Future Ready), euRobotics (ERF), Adra-e (ECS), and VISION.

These workshops showcased inspiring regional and national examples and how they utilized various European innovation instruments, such as EDIHs, DIHs, TEFs, AI Factories, EIT KICs, and EICs. This provided a better understanding of the factors contributing to the effectiveness of innovation models and offered learning opportunities for other regions and Member States.

The workshops inspired academic researchers to adopt a more entrepreneurial mindset, provided companies with insights into the available national and European innovation instruments and their added value, and fostered knowledge exchange with ecosystem builders and representatives from regional and national governments. In this way, the Task has significantly contributed to the early adoption of ADR technologies across European Member States.

The insights and knowledge gained from the interviews, discussions, and literature study on significant European and international AI developments and national AI strategy plans served as input for the workshops and this report. Five cases were selected for a more in-depth analysis of the development of their ADR ecosystems as illustrative and inspiring examples: two regional robotics cases (Twente and Odense) and three national AI cases (the Netherlands, Finland, and Croatia). These cases share both intriguing similarities and distinct differences in approaches, making them valuable examples for the workshops.

Adra has signed a Memorandum of Understanding with EIT Digital, a prominent international innovation network with extensive experience in technology adoption and startup support. This collaboration was actively supported, including regular joint taskforce meetings.

Adra has been supported in establishing the Topic Group titled “Innovation, Deployment, and Uptake of ADR Technologies.” The Task lead has been appointed as the coordinator of this topic group and several individuals who have actively contributed to workshop discussions have become members. As a result, the activities and accumulated knowledge related to this Adra-e task are seamlessly integrated into this Adra Topic Group.

Together, these efforts have laid a strong foundation for sustained collaboration, knowledge sharing, and strategic action to accelerate the responsible deployment and adoption of ADR technologies across Europe.

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