Value and Impact through Synergy, Interaction and coOperation of Networks of AI Excellence Centres

GRANT AGREEMENT NUMBER: 952070

Deliverable D4.4

European AI Trend Radar

Project title	Value and Impact through Synergy, Interaction and coOperation of Networks of AI Excellence Centres
Grant Agreement number	952070
Funding scheme	Horizon 2020
Start date of the project and duration	1 September 2020, 48 months
Project coordinator name	Holger H. Hoos (ULEI - UNIVERSITEIT LEIDEN)
Deliverable number	D 4.4
Title of the deliverable	European AI Trend Radar
WP contributing to the deliverable	WP4 - Academia-Industry Joint AI Forces
Deliverable type	R - Report
Dissemination level	Public
Due submission date	30.04.2024
Actual submission date	31.08.2024
Partner(s)/Author(s)	Janina Hoppstädter (DFKI), Kyra Kiefer (DFKI), Iris Merget (DFKI), Christian Müller (DFKI), Beatrice Bozzao (Intellera)
Internal reviewers	ULEI – Formal review Executive Board – Technical review
Final approval (Executive Board)	**Executive Board**

History of changes		
When	**Who**	**Comments**
29.04.2024	Janina Hoppstädter, Kyra Kiefer, Iris Merget, Christian Müller, Beatrice Bozzao	First version
15.05.2024	Janina Hoppstädter	Second version
23.07.2024	Janina Hoppstädter, Kyra Kiefer	Third version - EB comments solved

Confidentiality	
Does this report contain **confidential** information?	Yes ☐ No x
Is the report **restricted** to a specific group?	Yes ☐ No x *If yes, please precise the list of authorised recipients*:

Table of contents

Introduction and Methodology

Objectives of the VISION CSA and innovation activities

VISION – Value and Impact through Synergy, Interaction and coOperation of Networks of AI Excellence Centres – is a Coordination and Support Action (CSA) financed by the European Commission through the Horizon 2020 programme under the call for proposal H2020-ICT-48-2020. It has been proposed by a consortium of nine organisations coordinated by the University of Leiden (ULEI). The aim of the VISION project is to reinforce, interconnect and mobilise Europe's AI community and to orchestrate and accelerate Europe's transition to a world-leading position in the research, development, and deployment of AI technologies. More specifically, the project aims to reach this objective through the following activities:

- Theme Development Workshops: At least two Theme Development Workshops cutting across multiple AI Networks of Excellence (NoEs), bringing together researchers, industry representatives, and other stakeholders to identify industrial trends and needs, and match these to AI capabilities in Europe.
- European AI Trend Radar: The main results of the Theme Development Workshops as well as from similar events of the four NoEs will be summarised and complemented by a market analysis and trend foresights for providing a comprehensive overview of AI capabilities and challenges in Europe.
- New European Award for Top Young AI Talent: Creation of a Young AI Talents Award to recognise and celebrate the next generation of AI researchers in Europe.
- Human-Centric AI Education Programme: Development of standardised AI curricula to support current European educational offerings and to support educators in strengthening the digital and human centric skills of their students.
- Community-Shared Best Practices in AI: Sharing of best practices, such as the FSTP Vademecum, standardised AI curricula module for AI non-professionals, a template for Theme Development Workshops to help NoEs to organise such events most effectively, and mechanisms for industrial innovation and transfer of AI technologies.
- Integrated Roadmapping: Joint working groups for tackling challenges that span multiple NoEs, including a group on road-mapping and strategy development continuously updating each other on the strategic steps planned by the NoEs and working towards a common high-level alignment of objectives.

In particular, Work Package (WP) 4 targets academia-industry cooperation by providing market analysis and industrial trend foresight, while maximising the visibility of the NoEs within the European industrial community. More specifically, via WP4, VISION aims to bring together Europe's AI research and industry, identify industrial trends and needs, and optimally reap the socio-economic benefits a European AI powerhouse can bring for industry and society, as well as reinforce exchanges and synergies between research and industrial stakeholders, e.g. (European) Digital Innovation Hubs ((E)DIHs). This includes leveraging the insights from the Trend Radar, which synthesises the discussions from the Theme Development Workshops of TAILOR, HumanE AI Net, VISION, and CLAIRE AISBL. By coordinating the NoEs' connection with (E)DIHs, the Trend Radar provides a NoEs-specific perspective, emphasising practical, real-world AI applications and innovations relevant to Europe.

This approach fosters knowledge exchange and potential collaboration opportunities based on validated trends identified in both academic and industry research.

Methodology

The projects TAILOR, HumanE AI Net, VISION and CLAIRE AISBL organised a series of Theme Development Workshops (TDWs) which brought together AI researchers and industry professionals from various sectors. Their goal was to identify strategic AI research areas and promote collaborations. The workshops in which VISION played an important and prominent role, were focused on different themes, carefully selected to address specific sector needs and challenges:

1. **TDW Public:** AI in the Public Sector - 09/2021 Aimed at implementing Trustworthy AI systems and services in public administration
2. **TDW Mobility:** Future Mobility – Value of Data and Trust in AI - 10/2021- Delved into data and trust issues in AI applications for future mobility.
3. **TDW Health:** AI for Future Healthcare - 12/2021 - Explored AI applications in healthcare, emphasising Trustworthy AI to support personalised treatment.
4. **1st cross-cutting TDW:** AI: Mitigating Bias & Disinformation **-** 05/2022 - Addressed issues related to bias and disinformation in AI.
5. **TDW Manufacturing:** AI for Future Manufacturing - 05/2022 - Discussed the integration of AI in manufacturing, concentrated on identifying common goals between academia and industry.
6. **TDW Energy:** AI for Future Energy & Sustainability - 02/2023 - Aimed at exploring AI applications for sustainability and energy efficiency.
7. **2nd cross-cutting TDW:** Trusted AI – The Future of Creating Ethical & Responsible AI - 09/2023 - Focused on developing ethical and responsible AI practices.

This Trend Radar is a compilation that synthesises the insights and discussion from the Theme Development Workshops TAILOR, HumanE AI Net, VISION and CLAIRE AISBL. These workshops were forums where key players from various AI-related industry sectors and academic fields articulated strategic research directions in AI in Europe. The core of the Trend Radar report is based on the discussions held during these workshops, providing it with a distinctive, ground-up perspective on trends within Europe's AI landscape. To augment and validate the trends identified in the TDWs, a literature and market search was conducted. This approach ensures that the findings not only reflect expert opinions but are also confirmed by existing academic and industry research, increasing the reliability of the conclusions drawn. However, it is important to highlight that the core of the Trend Radar remains connected to the Theme Development Workshops. This connection offers a NoEs-specific perspective, emphasising practical, real-world applications and innovations in AI that are specifically relevant to Europe.
The process of compiling the Trend Radar involved the following approach:

- **Reassortment of Findings**

  We began by systematically reassorting the individual findings and statements collected from the various Theme Development Workshops thematically. This step was important to

understand the diverse perspectives and inputs gathered during these sessions. By grouping related findings according to topics, we could synthesise coherent themes and identify core areas of focus.

- **Keyword Generation for Literature Search**

  From the organised themes, a list of keywords was derived. These keywords were selected to capture the important aspects of the discussions and to guide the subsequent literature search. This ensured that the search was focused and relevant, enabling us to find academic and industrial publications that align with the workshop findings.

- **Literature Search and Validation**

  With the keywords, a literature search was conducted. The aim was to find existing research and publications that either support or provide additional context to the findings from the workshops. We restricted the search to contributions from 2020 onwards. This step was essential to validate the observations made during the workshops and to ensure that the Trend Radar is anchored in verified research.

- **Market Research for Selected Findings**

  For findings considered particularly significant or with potential market implications, additional market research was performed. This research aimed to assess the practical application and market acceptance of these trends, providing a more complete view that combines theoretical research with market realities.

- **Integration of Results**

  The final step involved integrating the insights from the literature search and market research back into the initial themes. This enriched the original workshop findings with a broader evidence base and market perspective.

In the synthesis of trends from the Theme Development Workshops, it's evident that the scope of identified trends varies significantly. Some trends are quite concrete, addressing specific technical or procedural issues within distinct sectors. For example, trends related to the implementation of AI in specific fields like healthcare or manufacturing often propose clear, actionable strategies. Conversely, other trends identified are broader and more general, encompassing wide-ranging implications for society and cross-sectoral challenges. The largest trends in scope have been found in areas concerning *Data* and *Trustworthy AI*. These areas enclose extensive discussions on the ethical, legal, and practical dimensions of AI deployment. For instance, trends in *Data* include the need for robust data management standards and the democratisation of big data pools, which are fundamental to the development and ethical use of AI technologies across various industries. Similarly, trends surrounding *Trustworthy AI* cover a holistic approach to AI development, including aspects of ethics, transparency, reliability, and safety, which require a broad and inclusive discussion to implement effectively.

The remaining part of the Trend Radar document will explore each trend category in detail. We go through the various trend categories that have been identified, discussing their implications, the current state of research and development, and potential future directions. Each category will be

analysed for its impact on different sectors, potential challenges, and the opportunities it presents for innovation and improvement.
The document covers both technical and non-technical aspects of AI trends, ensuring a comprehensive understanding of how these trends are influencing AI across Europe.

Broad Trends

In our exploration of AI's impact across various sectors based on the TDWs, we've identified broader trends that encompass relevant themes to the integration and acceptance of AI technologies. These broader trends - Education, Data, and Trustworthy AI - serve as foundations that guide more specific developments within individual sectors. In distinguishing these broader trends from the more specific ones, we aim to highlight their broader relevance and the role they play across all areas of AI application.

Education is important because it addresses the need for a well-informed workforce and an aware society that can engage with AI technologies effectively and ethically. Education in AI not only empowers professionals with the necessary skills but also prepares the general public to interact with AI-driven systems in their daily lives.

Data serves as the basis for most AI applications. The management, quality, security, and ethical use of data are important for the success of AI applications. This trend emphasises the importance of robust data infrastructures that ensure data integrity and privacy while enabling the powerful data analytics that drive AI innovations.

Trustworthy AI focuses on ensuring that AI systems are reliable, ethical, and transparent. This trend is important for building public trust and facilitating the integration of AI into critical areas such as healthcare, finance, and public administration.

Through the process of separating these broader trends from specific ones, we suggest allocating the necessary resources and attention to developing these foundational aspects, which are critical for the successful implementation of AI across various fields.

Education and Communication

The integration of AI into various sectors can be significantly impaired by a lack of understanding and communication between technical developers and end-users. To mitigate this challenge and fully harness the benefits of AI, there is a critical need for comprehensive and tailored educational programs [TDW Public]. These programs should aim to:

- Providing education that is specific to the needs of different sectors, we can promote a better understanding of how AI can be integrated into existing processes.
- Encouraging open and informed conversations between technical developers and sector-specific professionals can clarify the potential and practicalities of AI applications.
- Education programs must manage expectations by providing a realistic picture of what AI can and cannot do, preventing disillusionment and resistance to new technologies.

- Through education, the aim is to not only impart knowledge but also to cultivate a favourable perception of AI, thereby smoothing the path for its integration into workplace activities.
- An informed understanding of AI will enable its more effective integration, maximising the potential benefits and impacts for each sector.

Due to a lack of proper understanding, new technologies are marginalised in the processes of many sectors, and the dialogue with technical developers is complicated, reducing the potential benefits and impact of AI technologies and solutions. Tailored education for people in these sectors could be a possible approach to address this challenge, especially by focusing on a better understanding of the general framework for the potential introduction of AI in the processes of the respective sectors, balancing expectations, having a more concrete view of limits and capabilities of AI increasing acceptance of AI as part of the future working activities.

The discussions from the Public Sector Theme Development Workshop [TDW Public] have furthermore highlighted significant gaps in AI education and research within Europe. These discussions underscore the urgency of expanding AI training beyond traditional university degrees and incorporating it at various levels of education, including secondary schools and through specialised short courses. The workshop also brought to light the challenge Europe faces in attracting and retaining interdisciplinary AI researchers, due to bureaucratic obstacles like visa processes and entry requirements. Addressing these barriers is essential for fostering a dynamic and innovative AI research environment in Europe.

The TDW Mobility has shed further light on the differences between academia and industry needs in AI education and experience. In academia, AI researchers often find it challenging to obtain practical experience, which is crucial for industry readiness. On the other hand, the industry expresses a need for professionals who not only have deep theoretical knowledge but also practical skills that can be immediately applied to real-world problems. This difference has resulted in a talent gap, where the industry finds itself needing to timely upskill new employees to meet the demands of practical AI application.

Furthermore, the workshop recognized the critical role of public trust in the successful adoption of AI technologies. For the public to trust and accept AI, there must be effective communication strategies that convey information about AI advancements to the wider community, fostering understanding and engagement. Ensuring the public is well-informed about AI technologies is important for their widespread acceptance and integration into everyday life [TDW Mobility].

The TDW Energy contributes insights to the above discussion on education and communication within the AI sphere, expanding upon themes identified in those workshops. It emphasises the importance of interdisciplinary research and knowledge transfer, advocating for collaborative efforts between experts in energy, AI, and other relevant fields. This collaborative approach aligns with the broader trend identified in the Public Sector and Mobility workshops, which also stress the need for reducing the knowledge gap between different stakeholders.

Furthermore, the Energy TDW's call for AI competency courses at the middle and high school levels confirms the discussions from the Public Sector TDW that revealed a shortage of AI training at the university level. By initiating AI education earlier, students are better prepared for advanced AI studies at the tertiary level, potentially increasing the pool of experts with deep AI knowledge [TDW Energy].

The 1st and 2nd cross-cutting TDW´s have reinforced and expanded upon the findings from the sector-specific workshops regarding education and communication in AI. They stress that communication about AI should go beyond technical details and be contextualised within the current socio-political, ethical, and moral frameworks. This approach aligns with the realisation from the TDW Mobility that building public trust in AI requires communication strategies that go beyond just imparting technical knowledge. Moreover, the workshops identified the need for comprehensive strategies to inform the public about AI's potential and its limitations. This notion supports the TDW Energys´ implication that there's a pressing need for AI literacy among the wider population, not just within academia or industry sectors. In terms of collaboration, there is a clear call for a tighter integration between disciplines, especially between computer science, law, and ethics. This multidisciplinary engagement is essential for addressing the complex challenges AI presents, a theme that is consistent across the workshops. Such collaboration could help dealing with the legal and ethical dimensions of AI, which are of real importance for its integration into society.

Finally, the 2nd cross-cutting TDW's emphasis on tailored education for public sector workers to improve their understanding of AI reflects a broader consensus on the need for sector-specific AI training programs. These programs are essential for addressing challenges like understanding AI frameworks, managing expectations, and fostering a culture of AI acceptance across various levels of society. Collectively, these workshops underscore the importance of a holistic approach to AI education and communication, advocating for efforts to align technical AI development and its societal implications, ensuring that all sectors of society are prepared for the integration of AI into daily life.

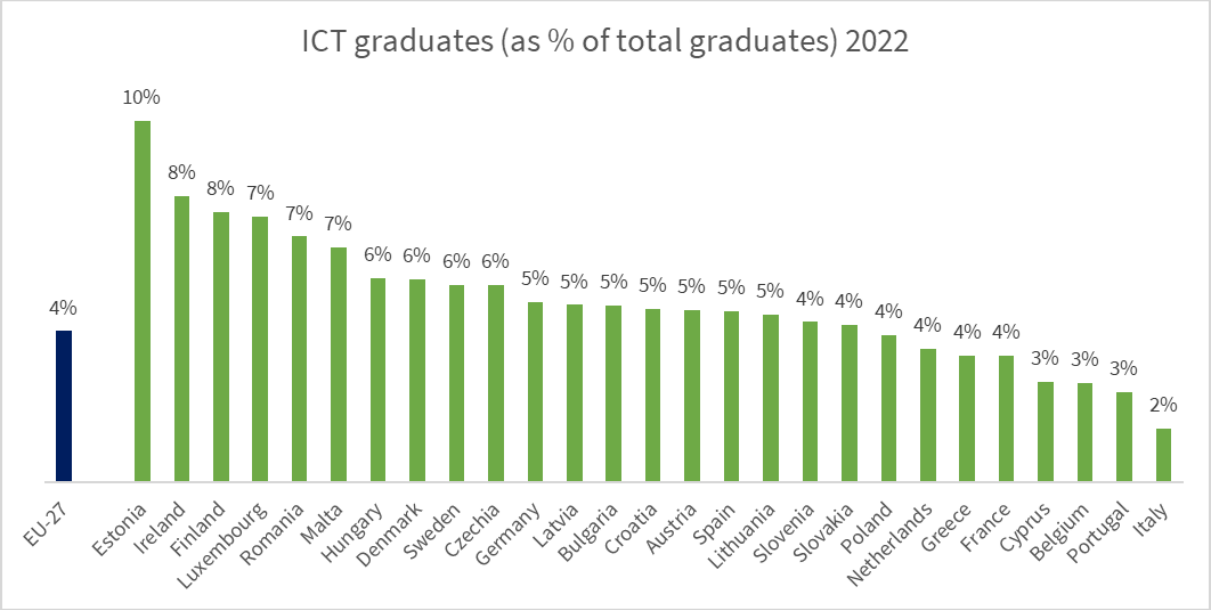
We will now investigate contemporary academic literature, recent EU statistics and industry publications. This will serve to confirm or provide additional context to the positions highlighted by the TDWs. By examining recent studies, articles, and white papers, we aim to confirm and contextualise the key findings about the importance of interdisciplinary collaboration, the necessity for inclusive AI education and effective communication strategies. This literature review will enable us to draw parallels between the insights gained from the workshops and the broader current discourse on AI.

The insights from Ulnicane et al. (2020) about the challenges AI technologies face due to a lack of understanding echo the concerns raised in the TDWs. They identify the necessity of creating a bridge through education between the developers of AI technologies and the end-users in various sectors. This concept aligns with the TDWs' emphasis on the importance of sector-specific AI education. Such tailored educational initiatives are important to prevent misconceptions and promote an environment where AI can be integrated more seamlessly into daily operations. The approach

outlined by Ulnicane et al. not only enhances understanding but also enables workers to engage meaningfully with AI technologies, ensuring that these innovations are leveraged to their full potential rather than marginalized due to a lack of knowledge or miscommunication. It's a call for educational reform and industry engagement to harmonise the relationship between AI's rapid development and its practical applications across sectors.

Market data further confirmed the trend identified during the TDWs in relation to AI education and research within Europe. The latest available Eurostat data (2022) portrayed in the Figure below revealed that graduates in the ICT field and related disciplines in the EU represented only 4% of all graduates, with relative peaks reported in Estonia (10%) and Ireland (8%), compared to Italy (2%), Portugal, Belgium and Cyprus (3%).

Figure 1 - ICT graduates in Europe (2022)



Source: Eurostat data, 2022

At the same time, it is interesting to highlight that the European Joint Research Center's 2023 EU Industrial R&D Investment scoreboard reveals other relevant insights with respect to research and AI in Europe. In fact, despite the leading Chinese role in terms of the absolute number of AI players (38% of all AI players), followed by the US (20%) and the EU (11%), according to the report, Europe displays a higher share of research institutions engaging in AI activities (11%) with respect to the other two countries (China, 9.5% and the US, 4%). It further underlines that in the period 2009-2022 China led in terms of AI research activities together with the EU, especially when considering the number of journal articles on AI. In fact, when taking into account AI-relevant publications the report reveals that the EU' share of activities was quite high (27%), followed by the US and China. However, as partly confirmed by the trends identified during some of the TDWs, when looking at patents as a measure of innovation, European activities with respect to other countries in this field were quite low (4%).

When looking at research activities in AI, the 2024 Stanford AI Index Report portrays another interesting picture and trend, revealing that leading companies in this sector are surpassing academia in terms of AI research, as shown by their investments in R&D budget and by the indicators in which universities typically excel, i.e. scientific publications, with Google and Microsoft publishing more than Stanford University in this field. Moreover, this Report underlines that in 2023 more than half (51) of the world's leading Machine Learning models came from companies, 21 from partnerships among companies and universities, 15 from universities and 2 from governments.

Public education on AI technologies, particularly in the healthcare sector, is of great importance for preventing potential confusion and fostering trust among patients. The use of deep learning in medical imaging, for instance, poses unique challenges in terms of comprehension and acceptance. As pointed out by Oren et al. (2020), a well-informed patient community can better appreciate the advantages and limitations of AI-powered diagnostics and treatments. This perspective aligns with the broader themes identified by the TDWs, which stress the importance of transparent communication to enhance understanding and mitigate scepticism around AI applications. Clear communication with patients about the role of AI in their care enhances healthcare outcomes and builds trust in medical technology advancements.

The integration of AI education into medical and health informatics curricula is gaining recognition as a relevant measure in readying healthcare professionals for the future. According to Sapci & Sapci (2020), this incorporation is recommended to equip medical students with the essential skills for proficiently utilising AI in healthcare environments. Prioritising AI in medical education aligns with the themes discussed in the TDWs, underscoring the importance of specific training that cumulates both the technical and ethical aspects of AI.
Moreover, it is interesting to underscore that, according to the Deloitte Center for Health Solutions, and the 2024 Life Sciences and Health Care Generative AI Outlook Survey, 75% of leading healthcare firms are experimenting with Generative AI or attempting to scale across the enterprise, 82% have or plan to implement governance and oversight structure for Generative AI, 92% of leaders see promise for Generative AI to improve efficiencies and 65% of leaders see promise to enable quicker decision-making. This trend paves the way for ever more digitised healthcare systems, underlining businesses' interest to embrace the AI-led transformation, which must be met by a prepared and well-informed healthcare force to effectively interact with and understand these new technologies for the benefit of patients.

Farid (2024) highlights the importance of such educational reforms for professionals to adapt to AI advancements, particularly in plastic surgery residency programs. This move towards a comprehensive AI-inclusive curriculum ensures that professionals are not only technologically skilful but also equipped to leverage AI for improved patient outcomes. Access to high-quality AI technology is also emphasised, underlining the need for hands-on experience with state-of-the-art tools.

The initiative to integrate AI education into middle school curricula, as proposed in studies by Park & Kwon (2023) and Chai et al. (2022), aligns directly with earlier discussions on the importance of AI literacy from a young age, as emphasised in the TDWs. Introducing core AI concepts during these

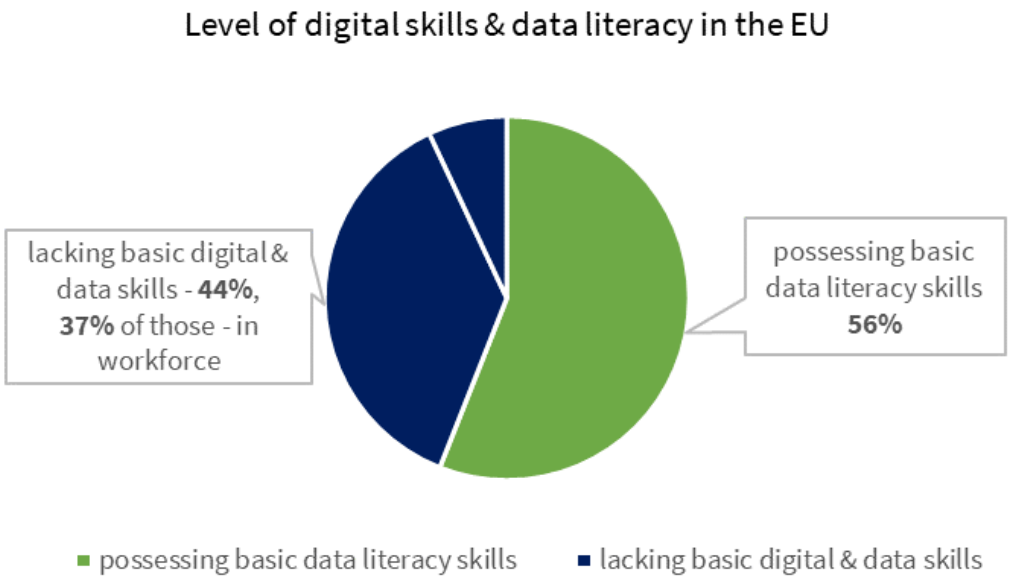
formative years allows students to develop a foundational understanding, preparing them for advanced studies and shaping their perceptions and acceptance of AI technologies in various aspects of life, including healthcare, as indicated by Sapci & Sapci (2020) and Farid (2024). This early education lays the basis for future professionals entering fields increasingly influenced by AI, ensuring continuity of knowledge from middle school to professional practice.

The studies by Hedderich et al. (2021) and Rainey et al. (2021) provide additional evidence that supports the TDWs' position on the importance of education in AI. These studies highlight tailored educational programs in medical imaging, advocating for enhanced understanding of AI among medical professionals to ensure its efficacy in clinical settings. This underlines the broader theme from the TDWs of specialised education for the effective integration of AI in various fields.

Furthermore, Peltier et al. (2023) show that training employees in AI can significantly improve operational practices, particularly in healthcare, which resonates with the TDWs' discussions on the necessity of education for employees across sectors.
Lastly, the successful role of educational campaigns in healthcare, particularly in increasing the acceptance of interventions like vaccination programs, as discussed in the studies by Papagiannis et al. (2020) and Pascucci et al. (2022), confirms the TDWs' suggestions about the broader impact of education on AI acceptance and uptake. These examples confirm the TDWs' position that a focus on tailored education is crucial for the adoption and effective application of AI technologies.

When looking at additional market data in relation to the above-mentioned findings, recent Eurostat numbers (2023) reveal that more than 90% of professional roles require a basic level of digital knowledge but almost half of Europeans i.e. 44% lack basic data literacy skills, including 37% of those in the workforce.

Figure 2 - Digital skills and data literacy in the EU (2023)

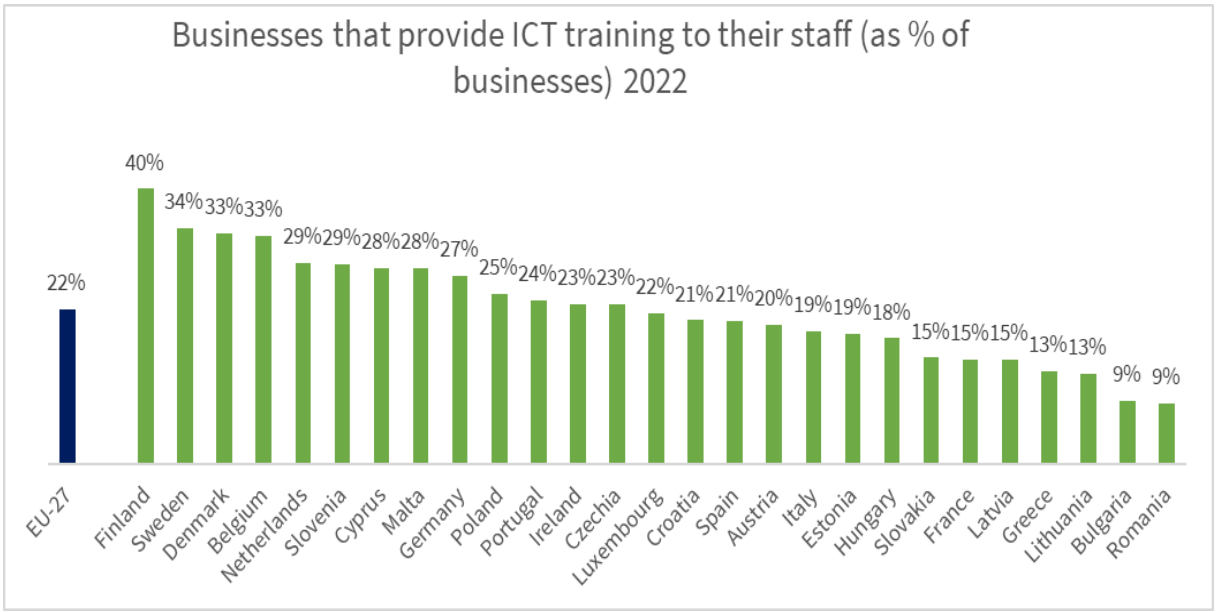


Source: Eurostat data, 2023

The above statistic confirms some of the findings emerging from the TDW´s, in relation to the existing gaps in AI education in Europe and to the urgency of expanding AI training beyond traditional university degrees and incorporating it at various levels of education to increase digital skills and data literacy of workers. A recent study by ARISA (AI Skills Needs Analysis, 2023) showed that although there is a growing supply of education in the AI field, it does not match the demand of AI professionals, both in quantitative and qualitative terms. The report further indicates that workers need to be skilled, reskilled or upskilled in order to close this gap. Additional data coming from a McKinsey survey (2022) showed that the most popular strategy to sourcing AI talent is upskilling technical and non-technical employees on AI. The recently published Europe data market study 2021-2023 outlined that the specific gap between supply and demand for data professionals, now estimated at 5% of the total number of data professionals in 2022, is expected to grow to 5.8% in 2025 and decrease to 5.6% in 2030.

At the same time, optimistic views from recent market studies foresee that by 2025, the EU's data democratisation efforts are projected to generate an increase of €1.5 trillion in economic value, underlining the central role of accessible data in fostering sustainable growth and development. In fact, additional data coming from Eurostat confirms the trend that emerged from the TDW Mobility with the industry finding itself in need to upskill new workers to meet the demands of AI innovation and implementation. As shown in the Figure below, on average 22% of EU businesses have provided training to their staff to develop or enhance their ICT skills in 2022. As also confirmed in the recent Stanford AI Index, when looking at business size, this share increases to 70% for large businesses, compared with 21% for SMEs.

Figure 3 – EU Businesses providing ICT training to their staff (2022)



Source: Eurostat data, 2022

Summary

The integration of artificial intelligence (AI) into various sectors is often hindered by misunderstandings between AI developers and end-users. To overcome this, it is important to implement targeted educational programs that:

- Develop sector-specific education to help professionals understand how AI can be integrated into their work.
- Encourage conversations between AI technologists and industry professionals to align technical capabilities with practical needs.
- Educate on AI's realistic capabilities and limitations to prevent disillusionment.
- Improve perceptions of AI to ease its adoption in professional environments.
- Focus on practical AI applications in education to address the gap between academic knowledge and industry requirements.

Policy Recommendations for Political Decision Makers:

- Implement AI competency courses at all educational levels, from secondary schools to professional training programs, to build a foundation of AI knowledge.
- Encourage partnerships between AI experts and other fields like law and ethics to address complex challenges.
- Develop clear communication strategies that explain AI advancements to the public, fostering broader understanding and trust.

Data

While data as a trend in AI has been prominent for at least the last decade, it continues to be significant. According to the European Data Market Study, the value of the data market (defined as the marketplace where digital data are exchanged as "products" or "services") reached €82 billion in 2023, with an increase of 11.1% from approximately €74 billion euros in 2022. This trend is underscored by its substantial representation in various TDW´s, highlighting that despite its longstanding status as a key driver of technological advancement, the challenges and opportunities surrounding data continue to demand attention. The prominence of data is not just about its role as the fuel for AI but also about the continuous advancements in data processing, storage, and analytics technologies that enhance its utility. The workshops have revealed a broad consensus on the importance of addressing data-related issues such as quality, accessibility, privacy, and security, which are of great importance for the sustainable development of AI technologies. The persistent focus on data in these discussions reflects its critical role in enabling more sophisticated, efficient, and Trustworthy AI systems.

Given the complexity and multifaceted nature of the data trend, our approach to exploring this topic will differ from how we handle other trends (except Trustworthy AI). Instead of reviewing all the Theme Development Workshop results on data and then examining the relevant literature, we will tackle each aspect of the data trend one by one.

Critical need to overcome information silos

The first aspect of the data trend focuses on the critical need to overcome information silos across different organisations and develop robust data sharing infrastructures. Insights from the TDW Public and the 1st Cross-Cutting Theme Development Workshop underscore several key challenges and solutions in this area:

1. The TDW Public emphasised the importance of designing governance models and technologies that facilitate data sharing. This is seen as crucial for enabling Trustworthy AI solutions by ensuring the availability, quality, and accessibility of data. Breaking down these silos can enhance collaboration and efficiency across different sectors and organisations, fostering more integrated and innovative AI applications.
2. The 1st cross-cutting TDW highlighted the difficulties associated with data sharing on a large scale, noting the tensions between technical, ethical, and regulatory aspects. There is a clear need for clarification and standardisation of data governance rules to reduce hesitancy among researchers and organisations regarding data sharing. This clarification would help in addressing concerns related to privacy, security, and compliance with regulations, making data exchange more seamless and trusted.

Both workshops highlight that effective data sharing, and the dismantling of information silos are relevant for leveraging data as a strategic resource. These discussions point towards a growing recognition of the complexities involved in data management and the need for sophisticated solutions that balance technical capabilities with ethical and legal considerations.

The literature strongly supports this. Tenopir et al. (2020) specifically address the complex relationship of technical, ethical, and regulatory factors that make data sharing particularly challenging. Their research highlights that researchers globally are influenced by diverse data sharing practices, which are shaped by regional requirements, regulations, and policies from key stakeholders like publishers, journals, and repositories. The complexities associated with data sharing are further underscored by Patrinos et al. (2022), who note that while data sharing is important for scientific advancement, it also introduces significant ethical and legal dilemmas. This highlights the balance that must be maintained between facilitating access to data for research and innovation and protecting individual rights and adhering to legal standards. Anger et al. (2022) also contribute to the understanding of the complexities involved in data sharing by emphasising that the challenges are multifaceted. They point out that conflicts in incentives, ethical considerations, and regulatory constraints all play significant roles in shaping data sharing practices. Rutella et al. (2020) further point out the specific challenges faced in the field of clinical research regarding data sharing. In this domain, data sharing not only encounters general ethical and regulatory hurdles but also must navigate conflicting interests among various stakeholders. These stakeholders include researchers, funding bodies, and participants, each with potentially divergent priorities and concerns.

The 1st cross-cutting as well as the TDW Public highlighted the potential benefits of establishing a large-scale European-wide infrastructure dedicated to enabling access to large datasets. This initiative

is seen as crucial for advancing research and development across various sectors by providing a centralised, accessible, and robust data-sharing platform. Such an infrastructure would facilitate the pooling of data resources, enhancing the scope and quality of research by providing researchers across Europe with access to a broad array of data.

When looking at other trends in this field, the EU is currently working on the development of EU-wide common and interoperable data spaces in specific strategic economic sectors for the European economy, i.e. Manufacturing, Mobility, Healthcare, Energy, Agriculture, Finance and the Public Sector. In fact, according to the Europe Big Data Market: Industry Analysis and Forecast (2024-2030), the highest percentage of the European data economy's value in 2023 (by Component, Deployment Mode, Application and Industry Vertical) was coming from the finance sector (Banking, Financial Services and Insurance), manufacturing & mining industry and healthcare. The report indicates that 25% of total Big Data spending in 2023 came from discrete manufacturing and banking due to the ongoing interest in process automation and fraud investigation, while the fastest growth until 2030 is projected to be seen in the professional services and healthcare domains, with a particular focus on the latter given the availability of patient data that can be used by analysts to better understand patients, improve performance, and obtain important medical insights from data, as also outlined during specific TDWs dedicated to this domain.

The literature supports the concept articulated here. Aarestrup et al. (2020) specifically mention the potential impact of such an infrastructure in the health sector, proposing the creation of a connected digital framework for health data across Europe. This infrastructure would facilitate the integration of research data with real-world datasets, enabling advancements in personalised and digital medicine. The availability of extensive, cross-border health data could transform patient care by making it more tailored and data-driven, thereby enhancing the effectiveness of medical interventions and the overall efficiency of healthcare systems. The view is further reinforced by Palojoki et al. (2021). They discuss the European Cross-Border Health Data Exchange, emphasising the importance of systematic openness and interoperability. Such an infrastructure would not only facilitate advancements in healthcare by enabling more seamless data exchange across borders but also underpin research capabilities by integrating diverse health data sets from across the European Union.

The Mobility sector, particularly within the automotive industry, emphasises the important role of data in developing new AI technologies such as autonomous driving solutions [TDW Mobility]. Data not only fuels the creation and testing of these technologies but is also integral to their implementation. However, the sector faces significant challenges related to the availability and usage of data. These issues hinder progress by restricting access to high-quality data needed for refining AI models and limit the industry's ability to fully exploit the potential of advanced analytics and machine learning in enhancing vehicle automation and safety features. These challenges must be addressed in advance the capabilities of autonomous driving and other AI-driven innovations in the sector of mobility.

Boavida & Candeias (2021) support the significance of data utilisation in the automotive sector, particularly in the context of AI adoption. They underline the importance of correctly interpreting external data, learning from it, and using these insights to achieve specific goals through flexible

adaptation. This process is fundamental in the development and enhancement of autonomous driving technologies, where the ability to accurately process and apply real-time data directly influences the effectiveness and safety of AI-driven systems.

The insights from the TDW Manufacturing also identified some strategic solutions to address these issues:

- Simplifying access to data by creating easy-to-obtain databases can help overcome barriers to data availability, making it easier for developers and researchers to innovate and improve AI technologies.
- Establishing better standards for data-driven programming and boosting investments in hardware are essential for secure supply chains and the development of fully trustworthy systems.
- Creating a big data pool that is accessible to everyone within the industry, and potentially even cross-industry, would allow for more comprehensive training on common datasets. This could facilitate easier understanding, quicker error identification, and overall improvement in AI systems.
- Modifying the rules regarding the certification of AI systems to include provisions, such as requiring AI systems to notify users when they cannot handle a situation, would enhance safety and trust.
- Increasing data transparency to ensure users understand the general behaviour of AI systems, including their capabilities and limitations, is vital. This understanding is central to mitigate mistrust and apprehension towards using AI technologies.

The TDW also highlighted two important conclusions about data:

- Data holds different values for different customers, and accurately estimating the value of data is critical.
- Data is inherently biased to some extent, and this bias must be acknowledged and managed. Additionally, there is no straightforward relationship between the value of data and the quantity of data.

The importance of synthetic data, as highlighted by the TDW Manufacturing, addresses a challenge in deploying deep learning methods, especially in environments where anomalies like defects are rare yet essential for training robust AI models. In such scenarios, solely relying on real-world data from production settings, which predominantly feature undamaged parts, proves inadequate for effectively training AI systems. The workshop proposed a solution involving the creation of synthetic data. This method demands simulating measurements based on scenes generated by parametric models or inspired by actual scenarios. Through the exploration of the parameter space of these models, it becomes feasible to create controlled, diverse training data that includes rare events or defects. This approach enables the development of a more comprehensive training dataset, enhancing the AI model's capability to accurately detect and respond to defects when they occur in real production environments.

The discussion on the use of synthetic data, particularly for enhancing deep learning methods in environments with scarce critical data, will be further explored in our upcoming section on Trustworthy AI. This section will discuss how synthetic data can be utilised not only to address data scarcity but also to improve the reliability and ethical considerations of AI systems.

Summary

The ongoing significance of data in AI underscores its role as a key technological driver. Themes from TDWs highlight the critical need for enhanced data management practices, focusing on quality, accessibility, privacy, and security to support sustainable AI development. Effective data sharing and breaking down information silos are recognized as important for leveraging data as a strategic resource.

Recommendations for Political Decision Makers:

- Develop standardised frameworks for data governance that facilitate data sharing while ensuring privacy and security.
- Invest in building robust, scalable data infrastructures that ensure wide access to quality data.
- Allocate resources towards data literacy programs to equip professionals with the skills necessary to harness data effectively.
- Implement regulations that balance technological innovation with ethical standards and privacy protection.
- Foster collaborations across different sectors to integrate diverse data insights and drive AI innovations forward.

Trustworthy AI

We come to the final broad trend identified through our TDW synthesis. Trustworthy AI stands out as a critical area demanding focused attention. This trend encompasses the essential elements that make AI systems reliable, ethical, and accountable. Trustworthy AI is not just about ensuring that AI technologies perform as expected but also about aligning their operations with societal values and legal standards. The importance of developing Trustworthy AI has been underscored repeatedly in various Theme Development Workshops, reflecting a collective acknowledgment of the need for AI systems that are not only technologically advanced but also socially responsible. As AI continues to integrate into every facet of life, ensuring its trustworthiness becomes important to foster public confidence and facilitate its broader acceptance.

Trustworthy AI is a difficult to grasp topic that should be perceived and approached holistically, including the areas of *Robustness & Security*, *Human-in-the Loop & Explainability*, *Ethics, Privacy & Liability*", *AI Governance & Monitoring*, *Verification & Validation*, *Data Availability/Quality*", *Reliability & Safety*. Accordingly, these topics should be addressed in a European AI research and innovation roadmap. On a political level, it would be beneficial to consider using the same terms in ongoing and future initiatives, especially in AI Ethics (Digital Ethics).

The TDW Manufacturing highlighted the necessity for fundamental research into AI systems, emphasising the need for collaborative efforts between academia and industry. This research is important for developing methods that can provide reliable guarantees about the performance and safety of AI systems. Such guarantees are essential not only for advancing technological capabilities but also for ensuring that these systems can be trusted by users and comply with regulatory standards. The focus on fundamental research reflects an understanding that robust AI applications require solid foundations in both theoretical and practical aspects, overcoming the differences between innovative concepts and their real-world applications [TDW Manufacturing].

Researchers from Stanford in collaboration with Accenture conducted a global responsible AI survey, whose preliminary results have been presented in the 2024 Stanford AI Report, which also revealed that more than half of the organisations surveyed reported privacy and data governance–related risks as pertinent to their AI adoption strategy (especially in Europe and Asia), while 29% identified fairness risks as highly relevant.[1]

The emphasis on guarantees within AI research is also highlighted by Juric et al. (2020), pointing out the necessity of developing AI systems that are not only functional but also reliably safe and trustworthy. The notion of "guarantee" in this context extends to ensuring that AI systems consistently adhere to expected standards of transparency, accountability, reliability, security, and performance. These are foundational to building trust in AI technologies, ensuring that they can be integrated safely into various sectors without causing unintended harm or operational discrepancies.
Seisenberger et al. (2022) underline the necessity of developing advanced verification techniques for AI systems that provide both explainability and guarantees, particularly in safety-critical domains such as railway systems. This focus on verification is a must in ensuring that AI applications in such sensitive areas adhere strictly to safety standards while remaining transparent in their decision-making processes.

The TDW Manufacturing furthermore emphasised the importance of research into various dimensions of trust, particularly focusing on the robustness of AI systems with respect to changing work conditions. This aspect of trust examines how well these systems can maintain their reliability and performance despite variations in their operational environment. Such research is required to guarantee that AI systems can adapt and continue to function effectively across a range of potentially fluctuating conditions, which is especially important in dynamic and unpredictable industrial settings.
Asan et al. (2020) confirms the critical importance of robustness in building trust in AI systems. Alongside other key factors such as explainability, fairness, transparency, and accountability, robustness is essential for ensuring that AI systems are reliable and can be trusted by users and stakeholders.

[1] The objective of the survey is to understand the current level of responsible AI adoption worldwide across 19 industries and 22 countries to develop an early snapshot around the responsible development, deployment, and use of generative AI. The survey covers the following dimensions: Reliability; Privacy and Data Governance; Fairness and Nondiscrimination; Transparency and Explainability; Human Interaction; Societal and Environmental Well-Being; Accountability; Leadership/ Principles/Culture; Lawfulness and Compliance; and Organisational Governance.

The insights from the TDW Manufacturing also emphasise the importance of interpretability and verification in AI systems to ensure effective human-machine collaboration and that the AI fulfils its intended purpose. Interpretability allows humans to understand and trust the decisions made by AI systems, which is crucial for true collaboration where both human and machine inputs are valued and integrated effectively.
Jungmann et al. (2022) underscore the relevant role of interpretability in cultivating effective human-machine collaboration. They highlight that interpretability not only helps in making AI systems more understandable for human operators but also builds trust, which is fundamental for successful partnerships between humans and machines. Additionally, they emphasise that transparency, fairness, and explainability are key characteristics that enhance trust and improve communication, thereby promoting successful collaboration.

Nußberger et al. (2022) further clarify the importance of interpretability in AI, noting that participants value this quality regardless of the accuracy of the AI systems. This underlines that interpretability is not merely an additional feature but a fundamental aspect of human-AI interaction. Users' appreciation for interpretability, even when it might come at the cost of some degree of accuracy, highlights its critical role in ensuring that AI systems are user-friendly and trustworthy.

This aspect is further confirmed in a number of other works. Bansal et al. (2021) underline that explainable AI improves collaboration by making the communication between users and AI systems more effective, thereby increasing the usability and acceptance of AI decisions. Taudien et al. (2022) note that human-AI collaboration optimally combines human strengths with AI capabilities, leading to better joint decision-making outcomes. Similarly, Schmidt & Biessmann (2020) demonstrate that interpretable machine learning methods can significantly enhance human-AI interaction by involving humans directly in the loop during AI processes. Lastly Süße et al. (2021) reflect on the growing prominence of human-AI integration as these interactions evolve, pointing to a future where collaboration between humans and AI becomes more seamless and inherently productive.

As a final contribution to this topic, the TDW Manufacturing emphasises the relevance of trustworthiness in systems deployed within highly sensitive environments like spacecraft or space stations. The requirement is that these systems must achieve an extremely high level of reliability and must be independently verified, beyond the assurances of the vendors who supply various system components. This insistence on independent verification ensures that every part of the system meets rigorous safety and performance standards before being implemented in such critical missions, where failure can have catastrophic consequences. This principle underlines the broader necessity for stringent testing and certification processes in manufacturing AI-driven or highly technical systems intended for use in critical and high-stakes environments.

Oche et al. (2024) conform the notion from the Manufacturing Theme Development Workshop about the need for reliability in systems used in the space industry. Their research underscores that the integration of AI into spacecraft and space stations demands a focus on reliability to ensure the safety and efficiency of operations. This highlights the universal requirement in aerospace applications for AI systems to undergo rigorous verification processes, ensuring they meet the highest standards of reliability necessary to support space missions effectively. Sabt & Farooqui (2023) highlight as well the

challenges associated with implementing AI in space missions, emphasising the necessity for AI systems to be highly reliable and robust. They point out that these systems must not compromise the core functions of spacecraft, stressing the importance of integrating AI technologies that support and enhance mission objectives without introducing risks to mission integrity. This perspective aligns with the broader understanding that AI applications in sensitive and high-stakes environments like space must meet stringent requirements to ensure both safety and functional efficacy. Aziz (2023) additionally supports the insights from the Manufacturing Theme Development Workshop regarding the critical need for reliability in AI applications for space missions. The study identifies existing limitations in fault detection techniques using AI in spacecraft, highlighting issues with accuracy and reliability. He also emphasises the need for further advancements to meet the stringent requirements of the space industry. Specifically, the study calls for a balance between prediction accuracy and reliability in the development of AI systems for space applications, underscoring that this balance is essential for ensuring the safe and efficient operation of spacecraft and space stations.

The TDW Mobility highlighted the potential impact of improving media coverage on the topic of Trustworthy AI. Enhancing the quality and reach of information shared through media about AI's reliability, ethical considerations, and safety could significantly increase the public's trust in AI technologies, suggesting that better-informed public discourse can lead to greater confidence and wider adoption of AI solutions in mobility and beyond [TDW Mobility].

The TDW Mobility further emphasises the significance of knowledge management in the AI community, particularly in spreading awareness about the concepts of trustworthy and explainable AI. This approach highlights the need for active knowledge sharing among AI researchers, developers, and practitioners to enhance understanding and implementation of these principles. Effectively managing and disseminating knowledge within the AI community will lead to a greater transparency and trust in AI systems.

One critical nuance in the public discourse about AI was particularly highlighted: the need to distinguish clearly between *Explainable AI (XAI)* and *Trustworthy AI*. This distinction is important because these concepts, while interconnected, focus on different aspects.

Huang (2022) highlights that while XAI focuses on the ability of AI systems to articulate their decision-making processes clearly, Trustworthy AI involves a broader consideration including ethical implications and reliability. This distinction is significant because it underscores that trustworthiness in AI transcends technical clarity to encompass ethical integrity and societal impact.

The insights from various studies highlight the intrinsic link between Trustworthy AI and XAI, confirming the perspectives shared in the TDW Mobility about their importance for the responsible development and deployment of AI systems. Thiebes et al. (2020) state that trustworthiness in AI encompasses key principles like beneficence, non-maleficence, autonomy, justice, and explicability, indicating a deep ethical framework that supports robust AI development. Markus et al. (2021) and Sabbatini & Calegari (2022) further suggest that XAI plays an important role in achieving trustworthiness by enhancing transparency and interpretability, making AI systems more comprehensible and, hence, more acceptable to users. Meanwhile, Nyrup & Robinson (2022) discuss

the challenges in defining these concepts precisely, reflecting ongoing academic and policy debates that underscore the complexity of these ideas. Efforts to clarify these terms, as noted by Arrieta et al. (2020) and Graziani et al. (2022), through frameworks and taxonomies, are essential for advancing the field and ensuring that AI technologies adhere to these foundational principles. Together, these studies reinforce the importance of integrating explainability and ethical standards into AI development, as advocated in the Mobility TDW, to foster systems that are not only technically proficient but also socially trusted.

Finally, the insights from the TDW Mobility highlight the importance of interactive and accessible AI systems to foster trust and acceptance among users and experts. They emphasise the necessity for robust and model-agnostic explanation methods that allow users to understand and trust various AI models and methods across different applications. This approach is critical in creating a user-friendly environment where AI's functionalities and decisions are transparent and comprehensible. Furthermore, the workshop points out the significance of both explainability and controllability in enhancing the acceptance of AI among workers. It stresses the need to consider a demographic structure of the workforce, ensuring that AI systems are inclusive and controllable by people from diverse backgrounds. This inclusion helps alleviate fears associated with AI deployment, ensuring that all workers can engage with these systems confidently and effectively.

The TDW Health emphasis on Robust and Explainable AI echoes the discussions from the TDW Manufacturing and TDW Mobility, highlighting the universal importance of these concepts across diverse sectors. The health sector specifically points to *Explainable AI by Design* as an element meant to increase trust and reliability in AI systems. This aligns with the insights from the TDW Manufacturing, which stressed the need for AI systems to meet high standards of reliability and verification, especially in critical applications like spacecraft. Similarly, the TDW Mobility underscored the significance of knowledge management to enhance understanding and implementation of trustworthy and Explainable AI.

The research by Schoenherr et al. (2023), Weitz et al. (2020), and Hoffman et al. (2023) collectively underscores the importance of explainability in AI systems and its impact on user trust and satisfaction. Schoenherr et al. emphasise the necessity of designing AI interfaces that are not only accurate but also explainable, enhancing trustworthiness. Weitz et al. contribute to this by suggesting that explanations should align with human behavioural frameworks to improve transparency and understandability for end-users. Hoffman et al. further highlight the significance of measuring the quality of these explanations, noting its crucial role in affecting user satisfaction, mental models, curiosity, trust, and overall performance in human-AI interactions. Together, these studies confirm that tailored, high-quality explanations are fundamental to fostering effective and trustworthy human-AI collaborations.

Summary

Trustworthy AI, as emphasised in various Theme Development Workshops, focuses on creating AI systems that are ethical, reliable, and accountable. These discussions highlight the importance of fundamental research and collaboration between academia and industry to develop AI systems that

align with societal values and legal standards. The key areas of focus include robustness, security, explainability, ethics, and privacy.

Recommendations for Political Decision Makers:

- Focus on integrating areas such as robustness, security, and explainability into the roadmap. Standardised terminology and approaches, particularly in AI ethics and governance.
- Support initiatives that enhance knowledge sharing among AI researchers, developers, and practitioners to improve the implementation of trustworthy and Explainable AI.
- Encourage partnerships between academia and industry to drive fundamental research on AI. This will help develop methods that provide reliable guarantees about AI system performance and safety.
- Support the development of AI systems that are inclusive and can be controlled by people from diverse backgrounds, fostering broader acceptance and confidence in AI technologies.
- Push for AI systems that are not only functional but also transparent and accountable, ensuring they consistently adhere to expected standards of performance and ethical practices.
- Develop and standardise advanced verification and validation techniques for AI systems, especially in safety-critical domains like transport and healthcare, to ensure they meet high safety standards.
- Encourage quality and informative media coverage about AI's reliability, ethical considerations, and safety to enhance public understanding and trust in AI technologies.

Specific Trends

We continue the Trend Radar exploring a series of more specific trends. These trends, identified through a synthesis of insights from various Theme Development Workshops and supported by recent literature and market data, whenever available, address narrower challenges and opportunities within the area of AI integration across different sectors. Each of these specific trends provides actionable insights that can guide the development, implementation, and adoption of AI technologies in focused areas.

Measurement of the Performance of AI ecosystems

The emphasis on AI Ecosystem Performance Measurement was highlighted in both the Public Sector Theme Development Workshop and the 1st Cross-Cutting Theme Development Workshop. These discussions underscored the need for systematic approaches to measure the effects of AI on society. This includes evaluating the performance of AI ecosystems to better understand how these technologies influence various sectors and the broader community [TDW Public, 2nd cross-cutting TDW].

This focus on performance measurement is intended to provide insights into the efficiency, reach, and impact of AI applications, ensuring that their deployment aligns with societal needs and ethical standards. By monitoring AI's effects comprehensively, stakeholders can make informed decisions to guide the development and regulation of AI technologies, thus fostering a responsible and beneficial AI landscape. This specific trend points towards a proactive approach in managing the integration of AI, aiming to maximise benefits while mitigating risks associated with its societal integration.

This finds substantial backing in recent academic literature. For instance, McKay et al. (2022) discuss the growing consensus among scholars and organisations on the importance of involving the public in decision-making processes concerning AI usage. This perspective underscores the critical role of public governance in AI research, highlighting the need for transparent, inclusive frameworks that allow for societal input and oversight. This supports the workshops' insights on measuring AI's societal impacts and stresses the importance of public engagement in shaping the governance structures around AI technologies. Such involvement ensures that AI development is not only technologically sound but also ethically attuned to public needs and values, enhancing trust and acceptance among the broader community.

The insights provided by Xu (2022) enhance our understanding of the specific impacts of AI within the manufacturing industry, emphasising how AI technologies not only augment human capabilities but also transform production tasks and boost productivity. This analysis highlights the necessity of incorporating economic indicators and productivity metrics into the systematic measurement of AI's effects. By doing so, we can gain a comprehensive view of AI's broader societal implications, particularly in terms of economic growth and industry evolution. This approach aligns with the broader themes discussed in the Theme Development Workshops, where the need for a multifaceted measurement of AI's impact was underscored. Including economic factors in these evaluations

provides a more rounded assessment of how AI technologies are reshaping industries and economies, offering valuable insights for policymakers, business leaders, and researchers.

Summary

The Trend Radar highlights the need to systematically measure the performance of AI ecosystems, emphasising the need to understand AI's impact on various societal sectors. This encompasses assessing AI's societal, economic, and productivity effects to guide its ethical and effective integration.

Recommendations for Political Decision Makers:

- Establish frameworks to regularly assess the impact of AI technologies across various sectors, focusing on both societal and economic outcomes.
- Encourage transparent decision-making processes that involve public input to ensure AI development aligns with societal values and needs.
- Include economic and productivity metrics in AI performance evaluations to provide a comprehensive view of how AI is reshaping industries and contributing to economic growth.

Research – Industry Collaboration

The TDW Manufacturing emphasises the critical role of research-industry collaboration in advancing the integration of AI technologies within the manufacturing sector. The workshop advocates for the establishment of joint labs that bridge the gap between academic research and industry needs. This collaborative approach is aimed at promoting a deeper understanding of AI applications and developing teams that are equipped to implement these technologies effectively in real-world industrial settings. This specific trend highlights the mutual benefits of such partnerships. For academia, it provides an opportunity to apply theoretical research in practical, industry-driven scenarios, enhancing the relevance and impact of research outcomes. For industry, collaborating with research institutions offers access to cutting-edge innovations and the expertise needed to tailor AI solutions to specific manufacturing challenges.
Joint labs foster innovation, where theoretical knowledge meets practical application, leading to more rapid development cycles and enhanced technological solutions that can significantly boost productivity and competitiveness in the manufacturing industry. This model of cooperation not only accelerates the adoption of AI but also ensures that its deployment is more closely aligned with the industry's evolving demands and challenges.

Luo et al. (2020) further substantiate the value of establishing joint AI labs, noting that such collaborative efforts significantly enhance the understanding and practical implementation of AI technologies across various sectors. Cultivating partnerships between academic research labs and industry settings bridges the gap between theoretical knowledge and real-world applications. This collaboration is relevant not only for adapting AI solutions to meet specific industrial needs but also for providing researchers with a deeper understanding of industrial processes.

Summary

The TDW Manufacturing stresses the importance of collaboration between research institutions and the manufacturing industry to advance AI integration. Establishing joint labs is promoted to merge academic research with practical industry applications, enhancing both AI development and implementation.

Recommendations for Political Decision Makers:

- Fund and facilitate the establishment of collaborative labs between academia and industry to accelerate AI innovation and application in manufacturing.
- Promote research that targets specific challenges in the manufacturing sector, ensuring that AI solutions are tailored to real-world needs.
- Create programs that enable the seamless exchange of knowledge and skills between researchers and industry professionals.

THE CROSS-NETWORK WORKING GROUP ON ACADEMIC-INDUSTRY COLLABORATION

Within its activities related to WP4 (Academic-Industry Joint AI Forces), the VISION project launched the Cross-network Working Group on Academic-Industry Collaboration in 2022 with representatives from each of the European Networks of Excellence Centres in AI, Data and Robotics projects (NoEs). Led by Inria as task leader of T4.3 (Support Industry-Research Collaboration) and with contributions from Intellera, the working group coordinated and supported efforts to maximise innovation potential through academic and industry collaboration through a cross-network perspective. This facilitation included three primary activities:

- sharing best practices to support innovation and transfer of AI technology in the NoEs;
- scouting for novel ideas and technology with industrial and societal relevance;
- support their integration and alignment with strategic roadmaps of the NoEs and the Adra SRIDA.

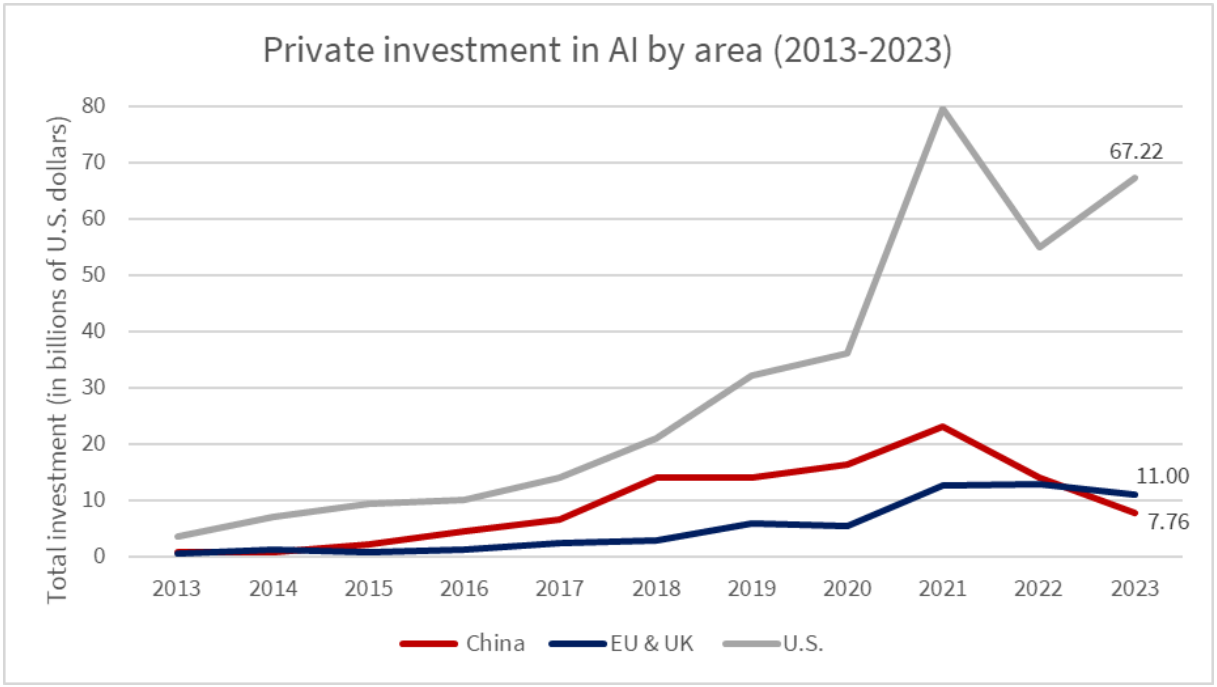
On behalf of the NoEs, VISION then published a report detailing **Best Practices for Academic and Industrial collaboration** within EU-funded Research & Innovation projects, which can be found on the VISION website as well as in Appendix B. It includes success stories from the academic-industry collaborative activities in the fields of Testing and validation, Financial support, Social interaction and networking, Education, and Support to the R&I ecosystem as well as an overview of best practices, challenges, recommendations for future projects, and avenues for replicability and sustainability.

Procurement, Advocacy and Market Creation

The TDW Public highlighted the significant role that governments can play in shaping AI markets through effective procurement strategies and market creation initiatives. This involves an approach where governments must carefully balance in-house development with procurement from private companies, organise investments strategically, and continuously update tender guidelines to meet evolving technological demands [TDW Public].

The 2024 Stanford AI Report underlines that, in 2023, "61 notable AI models originated from U.S.-based institutions, far outpacing the European Union's 21 and China's 15". Moreover, it specifies that private investment in AI in the US amounted to $67.3 B compared to less than $10B in the EU, confirming the trend that positions US companies as absolute market leaders. The Report further underlines that in 2023, private AI investment in the EU (including the UK) declined by 14.1% with respect to the previous year, while the US saw AI investments reach $67.2 billion, nearly 8.7 times more than China, the next biggest investor, with an increase of 22.1% in the same period. The graph below shows this trend over time, with the gap in private investments between the US and EU widening over time. According to the authors, this disparity becomes particularly relevant when looking at generative AI-related investments, with a gap of $21.1 billion in investments between the US and the combined investments of the EU plus United Kingdom.

Figure 4 - Private investment in AI by regional area (10-year trend)



Source: Stanford 2024 AI Index Report

In-house Development vs. Procurement - This decision is a must as it directly influences market dynamics and the landscape of innovation. Governments choosing to develop technology in-house can control the direction and focus of technological advancements but may miss out on the agility and innovative capabilities of the private sector.

Organizing Investments - The organisation of investments is needed for fostering an environment conducive to innovation and economic growth. Proper allocation of resources ensures that innovative projects have the necessary funding to succeed and contribute to the overall development of the AI sector. In this regard, the Stanford report also presents estimates of the costs experienced by the most innovative companies in this field training AI models, e.g. to train frontier models for OpenAI's GPT-4 and Google's Gemini Ultra the estimated cost was $78 million and $191 respectively. This

represents an enormous barrier to entry for the public sector, especially by universities or public research centres, which are not able to compete with this amount of investments.

Role of Public-Private Partnerships - Public-private partnerships serve as a relevant mechanism for driving innovation. These partnerships leverage the strengths of both the public and private sectors, resulting in synergistic outcomes that might not be achievable independently.

Updating Guidelines - As AI technology evolves, so too must the guidelines governing procurement processes. Adapting these guidelines ensures that they remain relevant and effective, facilitating smoother transitions and implementations of new technologies.

Through these strategic interventions, governments not only foster an environment conducive to innovation but also ensure that developments in the AI sector are sustainable and aligned with broader societal goals. This trend underscores the necessity for governmental agencies to be proactive and informed as they navigate the complex landscape of AI integration and market facilitation.

The TDW Health highlighted the role of advocacy in public healthcare systems and organisations, emphasising the need for increased funding opportunities and support for clinical data collection and sharing. This advocacy is required for enhancing healthcare delivery and research, enabling better resource allocation and the implementation of advanced technologies such as AI in healthcare settings [TDW Health].

Funding Opportunities: Advocacy efforts are needed to secure and expand funding that can drive innovations in healthcare, particularly those involving complex AI applications that require significant investment in technology and training.

Support for Clinical Data Collection and Sharing: Advocacy also plays a key role in promoting the importance of robust data practices. Effective data collection and sharing protocols are essential for the development of AI applications that can accurately diagnose, predict, and treat health conditions. These practices not only improve patient outcomes but also contribute to the broader body of medical knowledge and innovation.

Therefore, the Health TDW aims to ensure that AI technologies are effectively integrated into healthcare systems, enhancing their capability to deliver high-quality, efficient, and personalised care. This approach mirrors the broader discussions in the Public Sector TDW regarding the need for strategic governmental interventions to foster innovation and development within the AI sector, particularly in public services like healthcare.

Summary

The TDW Public discusses the impact of government strategies on AI market dynamics through procurement, in-house development, and public-private partnerships. The focus is on balancing in-house development with external procurement, organising strategic investments, and updating

procurement guidelines to foster innovation and meet evolving AI needs. Additionally, the TDW Health highlights the need for advocacy in healthcare to support AI integration, emphasising funding and data-sharing improvements.

Recommendations for Political Decision Makers:

- Strategically decide between in-house development and procurement from the private sector to stimulate market dynamics and innovation. Regularly revise procurement guidelines to align with the latest AI technologies and ensure effective implementation.
- Leverage public-private partnerships to combine strengths and accelerate AI innovation.
- Encourage and facilitate the collection and sharing of clinical data to enhance AI applications in healthcare, improving diagnosis and treatment outcomes.

Algorithm register

The 1st cross-cutting TDW emphasised the significance of developing and deploying algorithm registers as a strategic approach to addressing transparency and accountability concerns within AI applications across various sectors [1st cross-cutting TDW]. This initiative is particularly important as it seeks to:

- **Enhance Transparency -** Algorithm registers are designed to document and make visible the AI algorithms used within systems. This visibility is crucial for fostering an environment where the functions and decisions of AI systems are open to scrutiny, ensuring that AI operations are understandable and transparent to all stakeholders involved.
- **Promote Accountability -** By maintaining a detailed record of AI algorithms, these registers serve as a foundational tool for holding developers and users accountable for the AI systems deployed. This accountability is essential for building trust, particularly in sectors where AI decisions can have significant consequences.
- **Encourage Broader Participation -** The implementation of algorithm registers not only supports technical transparency but also encourages broader participation from the public and professionals in understanding and analysing AI applications. This inclusive approach is vital for demystifying AI technologies and enabling more informed discussions about their ethical and practical implications.

The TDW Public also highlighted the role of citizen science initiatives in enhancing public engagement with AI technologies. These initiatives are particularly valuable in the public sector as they involve the community directly in the scientific process, thereby democratising the development and scrutiny of AI technologies. Through the involvement of the citizens in these processes, the public sector can ensure that AI development is not only transparent but also inclusive, aligning with broader societal values and needs.

Citizen science initiatives programs encourage public participation in data collection, analysis, and the reporting of findings, which can be crucial for areas like environmental monitoring, healthcare, and urban planning. Such engagement helps demystify AI and promotes public understanding of its

implications and benefits, thereby supporting informed discussions about AI policy and its implementation.

This approach of involving citizen science aligns with the emphasis on transparency and accountability discussed in the Cross-Cutting Theme Development Workshop, particularly with the use of algorithm registers. Together, these strategies reinforce the commitment to making AI systems more accessible and comprehensible to the public, ensuring that AI development is guided by the principles of openness and community collaboration.

The significance of algorithm registers as highlighted in the literature supports the insights from the TDW Public and 1st and 2nd cross-cutting TDW´s. According to Kingsman et al. (2022) and Haresamudram et al. (2023), these registers are vital for enhancing transparency in AI deployment across a variety of sectors including public services, healthcare, law enforcement, retail, and e-commerce. Through documenting the use of algorithms, these registers provide insights into the decision-making processes behind AI systems. This documentation not only aids in understanding how AI decisions are made but also customise the accountability of AI deployments, ensuring that they are conducted in an ethical and transparent manner.

Ferrario (2021) expands the concept of algorithmic transparency, suggesting that it involves more than just making the algorithms visible. It also requires disclosing the criteria and objectives that guide the algorithmic decisions. This deeper level of transparency is essential for a thorough understanding of how and why decisions are made by AI systems.

Summary

The 1st cross-cutting TDW and TDW Public emphasised the importance of algorithm registers and citizen science initiatives to enhance transparency, accountability, and public engagement in AI applications. Algorithm registers help document AI algorithms, making their functions visible and scrutinizable, which is required to cultivate an environment of trust and informed participation. Citizen science initiatives further engage the public in AI technology development and scrutiny, promoting a democratised and inclusive approach.

Recommendations for Political Decision Makers:

- Establish and maintain comprehensive algorithm registers to enhance transparency and accountability in AI applications across various sectors. Ensure that algorithm registers are regularly updated and reviewed to reflect the evolving nature of AI technologies and practices.
- Encourage public participation in AI development through citizen science programs, which can help demystify AI and foster public trust.
- Require that AI deployments include detailed documentation of algorithms, criteria, and decision-making processes to ensure deeper transparency.

Federated Learning

The TDW Manufacturing has highlighted the potential benefits of federated learning in the context of large-scale manufacturing ecosystems. This approach to machine learning is particularly advantageous for industries that deal with vast amounts of data across multiple locations. By enabling the parallel processing of training sets, federated learning offers a more efficient and scalable method for improving manufacturing processes.

Additionally, *Federated Learning (FL*) adheres to the principles of *Privacy by Design* by allowing the training of AI models on partial datasets locally at different sites without the need to share the raw data itself. Instead, only the resulting models are combined and shared. This methodology not only enhances data privacy and security but also aligns with regulatory requirements such as GDPR, which are critical in industries handling sensitive or proprietary information [TDW Manufacturing].

The principles of *FL* as outlined in the TDW Manufacturing are further supported by Rieke et al. (2020). In their research, they describe how it facilitates *Privacy by Design*, emphasising that this methodology allows for the training of machine learning models on partial datasets in separate locations. This process prevents the need to share actual data among locations, as only the derived models from each dataset are combined. Such a strategy not only ensures the protection of sensitive data but also enhances the feasibility of deploying AI in environments with strict privacy requirements or logistical challenges.

Wang et al. (2023) further reinforce the effectiveness and security advantages of *Federated Learning* in their recent study. They highlight how *FL* facilitates machine learning by pooling data from multiple parties, enabling the collective training of models without requiring direct access to or sharing of the underlying data. This methodology not only preserves the security and privacy of the data but also harnesses the strength of diverse datasets, potentially enhancing the predictive power and accuracy of the models.

Shen et al. (2023) discuss the advancement of privacy-enhancing techniques within *Federated Learning*, specifically highlighting the use of personalised local differential privacy. This approach enhances the privacy framework of *FL* by adding an extra layer of security, allowing each participant in the federated network to apply differential privacy techniques to their data locally before it is used to train the shared model.

Summary

The TDW Manufacturing emphasised the advantages of *(FL)* in large-scale manufacturing, highlighting its efficiency in handling vast data across multiple locations. FL allows for local training of AI models on partial datasets without sharing raw data, enhancing privacy and security while complying with regulations like GDPR. Studies by Rieke et al., Wang et al., and Shen et al. support *FL's* benefits in preserving data privacy and boosting model effectiveness through privacy-enhancing techniques.

Recommendations for Political Decision Makers:

- Encourage the adoption of Federated Learning in industries with significant data privacy concerns or cross-location operations to enhance efficiency and compliance with privacy regulations.
- Back initiatives that implement Privacy by Design principles, particularly through Federated Learning, to ensure data protection from the outset of AI model training.
- Fund research and development of advanced privacy-enhancing techniques, like local differential privacy, to strengthen the security framework of Federated Learning.
- Foster collaboration among sectors that can benefit from Federated Learning, sharing best practices and advancements in AI without compromising data security.
- Regularly review and adapt data protection regulations to support innovative data processing techniques like Federated Learning, ensuring they remain effective and relevant.

Human-Machine Collaboration

While *Human-Machine Collaboration (HMC)* could be considered a part of the broader Trustworthy AI trend due to its focus on enhancing AI reliability and safety, it warrants specific attention due to its unique implications for the workforce and operational efficiency. In the context of manufacturing, the TDW has shed light on the significant role of *Human-Robot Collaboration (HRC)* [TDW Manufacturing].

The workshop emphasised that *HRC* is not about replacing human workers but rather integrating them more effectively into the production process. Robots can take over burdensome, repetitive, or hazardous tasks, which allows human workers to focus on aspects of the job that require human strengths such as flexibility, experience, and nuanced understanding. This collaborative approach leverages the best of both human and robotic capabilities, enhancing productivity while also maintaining job satisfaction and safety for human workers. This perspective from the TDW Manufacturing highlights the potential of HRC to transform traditional production lines into more advanced, efficient, and human-friendly systems.

The TDW Energy further elaborates on the nuances of Human-AI Collaboration, emphasising the creation of human-AI ecosystems and the concept of collaborative sustainable buildings. This approach underlines the importance of designing AI systems that not only support but actively collaborate with human teams, aiming for shared objectives and mutual support.
In these ecosystems, AI is seen not just as a tool but as a partner in the collaborative process, where the interaction between humans and machines is crucial for success. The field of human-machine interaction plays an important role here, focusing on understanding and integrating human preferences, aggregating these inputs, and accurately interpreting human requirements to enhance cooperation. This ensures that AI systems are not only efficient but also dedicated to the specific needs and contexts of their human counterparts, making the collaboration more effective and goal-oriented [TDW Energy].

The significance of *Human-Robot Collaboration* highlighted in both the TDW Manufacturing and TDW Energy is further supported by recent literature. Konstant (2023) discusses the evolving field of *HRC*,

focusing on the use of collaborative robots (cobots). These cobots are designed to complement human abilities within the production process, harnessing human decision-making skills and flexibility alongside the efficiency and precision of robotic technology. This synergy allows cobots to be integrated into workflows where they can perform repetitive or precision-based tasks while humans manage areas requiring critical thinking and adaptation. The combination enhances overall productivity and safety, reducing the physical strain on human workers and minimising errors in tasks that demand consistent precision.

Wang & Zhao (2023) further emphasise the benefits of *Human-Robot Collaboration* , highlighting how this partnership strategically leverages human cognitive abilities and problem-solving skills with robotic efficiency and precision. This collaboration is designed to make the most of the unique strengths of both humans and robots, creating a more integrated and productive work environment.

This approach not only enhances the efficiency of the manufacturing process but also ensures that complex problems which require human ingenuity and adaptability can be addressed more effectively. By allowing humans to focus on tasks that require higher cognitive skills while robots handle repetitive or precision-demanding tasks, *HRC* maximises productivity and innovation in industrial settings. This integration combines the best capabilities of both human workers and robotic systems, leading to improved outcomes in terms of both speed and quality of the production process.

Summary

Human-Machine Collaboration (HRC) in manufacturing and energy sectors focuses on integrating human strengths with robotic capabilities to enhance productivity, safety, and job satisfaction. This collaboration is not about replacing humans but augmenting their capabilities with robots that handle repetitive or hazardous tasks, allowing humans to focus on complex problem-solving. HRC creates advanced, efficient systems where robots are partners, not just tools, effectively supporting human workers.

Recommendations for Political Decision Makers:

- Support initiatives that foster human-machine collaboration in industrial sectors, ensuring that robots are used to enhance, not replace, human workers.
- Fund training programs that equip workers with the skills to effectively collaborate with robots, focusing on areas where human intuition and decision-making are crucial.
- Support the development and deployment of collaborative robots (cobots) that can safely work alongside human workers, enhancing their capabilities without compromising safety.
- Offer incentives for research into the dynamics of human-robot interaction, aiming to improve the integration and efficiency of cobots in various industries.
- Ensure that regulations keep pace with technological advancements in robotics, addressing both safety concerns and employment impacts in sectors utilising *HRC*.

Digital Twins

While the topic of *Digital Twins* is also addressed under the broader DATA trend, we've accepted some redundancy here to emphasise its unique applications and benefits within specific contexts. The TDW Manufacturing provided insightful discussions on how *Digital Twins* can be utilised not only for engineering purposes but also for enhancing user engagement and understanding [TDW Manufacturing].

In the manufacturing sector, *Digital Twins* are used to create highly detailed digital models that mirror physical objects. The workshop highlighted that these digital models are particularly useful in understanding and managing the constraints that physical products encounter throughout their lifecycle. By evolving the *Digital Twin* in parallel with the use of the actual product, both engineers and users gain a deeper and more dynamic understanding of these constraints. This ongoing evolution of the *Digital Twin* allows for real-time insights and adjustments, which can significantly enhance the efficiency and effectiveness of both product development and operational processes.

This application of *Digital Twins* not only improves the engineering side by providing a comprehensive view of the product's performance and issues but also empowers users by offering them greater visibility and input into the product's lifecycle and constraints. This dual benefit underscores the importance of integrating *Digital Twins* into modern manufacturing practices to bridge the gap between static product development and dynamic product use.

Summary

Digital Twins in manufacturing create precise digital replicas of physical objects, providing engineers and users real-time insights into product constraints and performance, which enhances product development and operational processes.

Recommendations for Political Decision Makers:

- Encourage the use of Digital Twins in manufacturing for improved efficiency and engagement.
- Develop industry-wide standards for Digital Twin technology to ensure consistency and security.

Edge Computing & High-Performance Communication Technologies

The discussions in both the TDW Manufacturing and TDW Energy have highlighted the transformative potential of combining Edge Computing and Edge AI with advanced communication technologies like 5G. This combination is seen as an enabler for industrial and energy process improvements, supporting more efficient, scalable, and responsive systems.

The integration of Edge Computing and Edge AI, supported by 5G, is poised to revolutionise industrial processes. This technology allows for real-time data processing at the edge of the network, closer to where data is generated. This proximity reduces latency, enhances data processing speed, and improves the reliability of industrial operations. Such capabilities are very important in manufacturing

settings where timely and efficient data analysis can lead to significant improvements in production processes, maintenance, and overall operational efficiency.

Similar principles apply in the energy sector, where scalability becomes a critical factor, especially in large and interconnected systems. The TDW Energy emphasised the potential of Edge Computing to handle the vast amounts of data generated by modern energy systems. This approach not only facilitates faster processing and decision-making but also supports decentralised coordination mechanisms, which are essential for managing complex energy networks effectively.

These discussions across both workshops underline the growing importance of Edge Computing and Edge AI in driving forward industrial and energy innovations, with the backing of high-performance communication technologies like 5G to ensure that these systems are both robust and adaptable to future challenges.

Summary

Edge Computing combined with 5G and Edge AI is transforming manufacturing and energy sectors by enabling real-time, efficient data processing close to data sources, reducing latency, and improving system responsiveness.

Recommendations for Political Decision Makers:

1. Promote the expansion of 5G networks to enhance Edge Computing capabilities.
2. Encourage the integration of Edge Computing and Edge AI in industrial and energy sectors to improve operational efficiency.

Energy Efficiency using AI

The TDW Energy underscored the significant potential of AI-enabled software solutions to enhance energy efficiency in various systems. The focus on leveraging AI for energy consumption anomaly detection and time-series forecasting represents a strategic approach to managing and optimising energy use more effectively [TDW Energy].

Energy Consumption Anomaly Detection - AI algorithms have the capability to detect patterns and anomalies in energy usage that might escape human observation. Early detection of irregularities enables these systems to prompt timely interventions, addressing inefficiencies or faults and consequently reducing unnecessary energy consumption and costs.

Time-Series Forecasting - AI's ability to estimate energy needs based on historical data and real-time inputs allows for more precise adjustments to energy production and distribution. This capability ensures that energy supply closely aligns with actual demand, minimising wastage and optimising resource use.

These AI-driven methods not only result in significant energy savings but also enhance the overall sustainability of energy systems. Through the integration of advanced analytics and predictive

capabilities, the energy sector can attain higher operational efficiency, advancing broader environmental and economic objectives.

Summary

AI-driven software is enhancing energy efficiency by detecting anomalies in usage and forecasting future energy needs, optimising energy production and distribution.

Recommendations for Political Decision Makers:

- Promote the adoption of AI technologies for energy anomaly detection and forecasting to optimise energy use.
- Fund initiatives aimed at advancing AI algorithms tailored for the energy sector.

Conclusions

As we draw this extensive exploration to a close, it is clear that the European AI Trend Radar has significantly enhanced our understanding of the current landscape and future directions of AI research and application in Europe. The systematic reassortment of findings from the Theme Development Workshops (TDWs), coupled with rigorous literature and market research, has provided a robust foundation for identifying and validating key trends in AI.

One of the standout themes is the critical importance of Trustworthy AI. This encompasses ensuring that AI systems are not only functional but also align with societal values and legal standards. The emphasis on robustness, security, explainability, ethics, privacy, liability, governance, and monitoring reflects a comprehensive approach to developing AI technologies that are reliable, ethical, and transparent. This holistic perspective is essential for fostering public trust and facilitating broader acceptance of AI across various sectors .

Another major theme is the role of education and communication in bridging the gap between AI development and societal needs. Effective AI education is crucial for preparing a well-informed workforce capable of engaging with AI technologies ethically and effectively. This includes not only professionals but also the general public, ensuring that everyone is equipped to interact with AI-driven systems in daily life. Moreover, interdisciplinary collaboration and knowledge transfer are vital for addressing the complex challenges posed by AI, reinforcing the need for continuous dialogue between academia, industry, and other stakeholders .

Data management and trustworthy AI have emerged as foundational aspects underpinning the successful integration of AI into various sectors. The need for robust data infrastructures that ensure data integrity and privacy, while enabling powerful analytics, cannot be overstated. This trend underscores the critical role of data as a strategic resource, driving AI innovations while maintaining ethical standards and public trust .

The practical implications of these findings are far-reaching. For policymakers, the recommendations include developing standardised frameworks for data governance, investing in scalable data infrastructures, promoting data literacy, and fostering collaborations across sectors. Such measures will ensure that AI development is aligned with both technological advancements and societal values, paving the way for a responsible and inclusive AI landscape .

Looking ahead, the establishment of joint labs and collaborative initiatives between academia and industry will be crucial. These partnerships will facilitate the practical application of theoretical research, enhance innovation cycles, and ensure that AI solutions are tailored to meet real-world challenges. This model of cooperation is pivotal for accelerating the adoption of AI technologies and ensuring that their deployment is both effective and ethical .

In conclusion, the insights gained from the European AI Trend Radar highlight the need for a multifaceted approach to AI development. By addressing the ethical, educational, and practical dimensions of AI, we can ensure that these technologies are not only cutting-edge but also socially responsible and widely accepted. The continued collaboration between various stakeholders will be essential for navigating the complexities of AI integration and harnessing its full potential for the benefit of society.

Appendix A: List of references

Aarestrup, F. M., Albeyatti, A., Armitage, W. J., Auffray, C., Augello, L., Balling, R., ... & Van Oyen, H. (2020). Towards a European health research and innovation cloud (HRIC). Genome medicine, 12, 1-14.

Aziz, T. A., Salama, G. I., Mohamed, M. S., & Hussein, S. (2023, November). Spacecraft fault detection and identification techniques using artificial intelligence. In Journal of Physics: Conference Series (Vol. 2616, No. 1, p. 012025). IOP Publishing.

Anger, M., Wendelborn, C., Winkler, E. C., & Schickhardt, C. (2022). Neither carrots nor sticks? Challenges surrounding data sharing from the perspective of research funding agencies—A qualitative expert interview study. PLoS One, 17(9), e0273259.

Arrieta, A. B., Díaz-Rodríguez, N., Del Ser, J., Bennetot, A., Tabik, S., Barbado, A., ... & Herrera, F. (2020). Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. Information fusion, 58, 82-115.

Asan, O., Bayrak, A. E., & Choudhury, A. (2020). Artificial intelligence and human trust in healthcare: focus on clinicians. Journal of medical Internet research, 22(6), e15154.

Bansal, G., Nushi, B., Kamar, E., Horvitz, E., & Weld, D. S. (2021). Is the most accurate ai the best teammate? optimizing ai for teamwork. In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 35, No. 13, pp. 11405-11414).

Boavida, N., & Candeias, M. (2021). Recent automation trends in portugal: implications on industrial productivity and employment in automotive sector. Societies, 11(3), 101.

Chai, C. S., Chiu, T. K., Wang, X., Jiang, F., & Lin, X. F. (2022). Modeling Chinese secondary school students' behavioral intentions to learn artificial intelligence with the theory of planned behavior and self-determination theory. Sustainability, 15(1), 605.

Deloitte. (2023). From code to cure, how Generative AI can reshape the health frontier | Unlocking new levels of efficiency, effectiveness, and innovation. Retrieved from LSHC_7886671_AIandHC_POV_FINAL_PM_111623 (deloitte.com).

Eurostat. (2023). Digitalisation in Europe - 2023 edition. [Interactive publication]. Retrieved from Digitalisation in Europe - 2023 edition - Eurostat (europa.eu).

Farid, Y., Gutierrez, L. F. B., Ortiz, S., Gallego, S., Zambrano, J. C., Morrelli, H. U., & Patron, A. (2024). Artificial intelligence in plastic surgery: insights from plastic surgeons, education integration, ChatGPT's survey predictions, and the path forward. Plastic and Reconstructive Surgery–Global Open, 12(1), e5515.

Farrell, E., Minghini, M., Kotsev, A., Soler-Garrido, J., Tapsall, B., Micheli, M., Posada, M., Signorelli, S., Tartaro, A., Bernal, J., Vespe, M., Di Leo, M., Carballa-Smichowski, B., Smith, R., Schade, S., Pogorzelska, K., Gabrielli, L., & De Marchi, D. (2023). European data spaces: Scientific insights into data sharing and utilisation at scale. Joint Research Centre. https://doi.org/10.2760/400188

Ferrario, A. (2022). Design publicity of black box algorithms: a support to the epistemic and ethical justifications of medical AI systems. Journal of Medical Ethics, 48(7), 492-494.

Gómez-González, E., & Gómez, E. (2023). Artificial intelligence for healthcare and well-being during exceptional times: A recent landscape from a European perspective. : Publications Office of the European Union. https://doi.org/10.2760/404140.

Graziani, M., Dutkiewicz, L., Calvaresi, D., Amorim, J. P., Yordanova, K., Vered, M., ... & Müller, H. (2023). A global taxonomy of interpretable AI: unifying the terminology for the technical and social sciences. Artificial intelligence review, 56(4), 3473-3504.

Haresamudram, K., Larsson, S., & Heintz, F. (2023). Three levels of AI transparency. Computer, 56(2), 93-100.

Hedderich, D. M., Keicher, M., Wiestler, B., Gruber, M. J., Burwinkel, H., Hinterwimmer, F., ... & Navab, N. (2021, September). AI for doctors—a course to educate medical professionals in artificial intelligence for medical imaging. In Healthcare (Vol. 9, No. 10, p. 1278). MDPI.

Hoffman, R. R., Mueller, S. T., Klein, G., & Litman, J. (2023). Measures for explainable AI: Explanation goodness, user satisfaction, mental models, curiosity, trust, and human-AI performance. Frontiers in Computer Science, 5, 1096257.

Huang, J. (2022). Digital engineering transformation with trustworthy AI towards industry 4.0: emerging paradigm shifts. Journal of Integrated Design and Process Science, 26(3-4), 267-290.

Jungmann, F., Ziegelmayer, S., Lohoefer, F. K., Metz, S., Müller-Leisse, C., Englmaier, M., ... & Braren, R. F. (2023). Algorithmic transparency and interpretability measures improve radiologists' performance in BI-RADS 4 classification. European Radiology, 33(3), 1844-1851.

Joint Research Centre. (2023). EU Industrial R&D Investment Scoreboard. https://doi.org/10.2760/506189

Joint Research Centre. (2022). AI Watch: National Strategies on Artificial Intelligence: A European Perspective. JRC Technical Report, : Publications Office of the European Union.

Kingsman, N., Kazim, E., Chaudhry, A., Hilliard, A., Koshiyama, A., Polle, R., ... & Mohammed, U. (2022). Public sector AI transparency standard: UK Government seeks to lead by example. Discover Artificial Intelligence, 2(1), 2.

Konstant, A., Orr, N., Hagenow, M., Senft, E., Gundrum, I., Mutlu, B., ... & Radwin, R. G. (2023, September). Human-Robot Collaboration in a Sanding Task. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 67, No. 1, pp. 845-846). Sage CA: Los Angeles, CA: SAGE Publications.

Luo, Y., Wang, M., Wan, C., Cai, P., Loh, X. J., & Chen, X. (2020). Devising Materials Manufacturing Toward Lab-to-Fab Translation of Flexible Electronics. Advanced Materials, 32(37), 2001903.

Markus, A. F., Kors, J. A., & Rijnbeek, P. R. (2021). The role of explainability in creating trustworthy artificial intelligence for health care: a comprehensive survey of the terminology, design choices, and evaluation strategies. Journal of biomedical informatics, 113, 103655.

Micheletti, G., Raczko, N., Moise, C., Osimo, D., & Cattaneo, G. (2024). European Data Market Study 2021–2023: Deliverable D2.8 Final Report on Policy Conclusions. [Publication Date: 02.02.2024]

McKay, F., Williams, B. J., Prestwich, G., Treanor, D., & Hallowell, N. (2022). Public governance of medical artificial intelligence research in the UK: an integrated multi-scale model. Research Involvement and Engagement, 8(1), 21.

McKinsey & Company. (2023). The state of AI in 2023: Generative AI's breakout year. Retrieved from The state of AI in 2023: Generative AI's breakout year | McKinsey.

Nussberger, A. M., Luo, L., Celis, L. E., & Crockett, M. J. (2022). Public attitudes value interpretability but prioritize accuracy in Artificial Intelligence. Nature Communications, 13(1), 5821.

Nyrup, R., & Robinson, D. (2022). Explanatory pragmatism: a context-sensitive framework for explainable medical AI. Ethics and information technology, 24(1), 13.

Oche, P. A., Ewa, G. A., & Ibekwe, N. (2021). Applications and challenges of artificial intelligence in space missions. IEEE Access.

Oren, O., Gersh, B. J., & Bhatt, D. L. (2020). Artificial intelligence in medical imaging: switching from radiographic pathological data to clinically meaningful endpoints. The Lancet Digital Health, 2(9), e486-e488.

Palojoki, S., Vakkuri, A., & Vuokko, R. (2021). The European cross-border health data exchange: focus on clinically relevant data. In Public Health and Informatics (pp. 442-446). IOS Press.

Papagiannis, D., Malli, F., Raptis, D. G., Papathanasiou, I. V., Fradelos, E. C., Daniil, Z., ... & Gourgoulianis, K. I. (2020). Assessment of knowledge, attitudes, and practices towards new coronavirus (SARS-CoV-2) of health care professionals in Greece before the outbreak period. International journal of environmental research and public health, 17(14), 4925.

Park, W., & Kwon, H. (2024). Implementing artificial intelligence education for middle school technology education in Republic of Korea. International journal of technology and design education, 34(1), 109-135.

Patrinos, D., Knoppers, B. M., Laplante, D. P., Rahbari, N., & Wazana, A. (2022). Sharing and safeguarding pediatric data. Frontiers in Genetics, 13, 872586.

Pascucci, D., Nurchis, M. C., Lontano, A., Marziali, E., Vetrugno, G., Cambieri, A., ... & Laurenti, P. (2022). Flu and COVID-19 vaccination: What happens to the flu shot when the campaigns overlap? Experience from a large Italian research hospital. Vaccines, 10(6), 976.

Peltier, J. W., Dahl, A. J., & Schibrowsky, J. A. (2023). Artificial intelligence in interactive marketing: A conceptual framework and research agenda. Journal of Research in Interactive Marketing, (ahead-of-print).

Rainey, C., O'Regan, T., Matthew, J., Skelton, E., Woznitza, N., Chu, K. Y., ... & Malamateniou, C. (2021). Beauty is in the AI of the beholder: are we ready for the clinical integration of artificial intelligence in radiography? An exploratory analysis of perceived AI knowledge, skills, confidence, and education perspectives of UK radiographers. Frontiers in digital health, 3, 739327.

Rieke, N., Hancox, J., Li, W., Milletari, F., Roth, H. R., Albarqouni, S., ... & Cardoso, M. J. (2020). The future of digital health with federated learning. NPJ digital medicine, 3(1), 1-7.

Rutella, S., Cannarile, M. A., Gnjatic, S., Gomes, B., Guinney, J., Karanikas, V., ... & Cesano, A. (2020). Society for immunotherapy of cancer clinical and biomarkers data sharing resource document: volume I—conceptual challenges. Journal for immunotherapy of cancer, 8(2).

Sabbatini, F., & Calegari, R. (2022). Evaluation metrics for symbolic knowledge extracted from machine learning black boxes: A discussion paper. arXiv preprint arXiv:2211.00238.

Al Sabt, I., & Farooqui, M. O. (2023). Navigating the Convergence of Artificial Intelligence and Space Law: Challenges and Opportunities. HighTech and Innovation Journal, 4(1), 55-64.

Schmidt, P., & Biessmann, F. (2020). Calibrating human-ai collaboration: Impact of risk, ambiguity and transparency on algorithmic bias. In Machine Learning and Knowledge Extraction: 4th IFIP TC 5, TC 12, WG 8.4, WG 8.9, WG 12.9 International Cross-Domain Conference, CD-MAKE 2020, Dublin, Ireland, August 25–28, 2020, Proceedings 4 (pp. 431-449). Springer International Publishing.

Sapci, A. H., & Sapci, H. A. (2020). Artificial intelligence education and tools for medical and health informatics students: systematic review. JMIR Medical Education, 6(1), e19285.

Schoenherr, J. R., Abbas, R., Michael, K., Rivas, P., & Anderson, T. D. (2023). Designing AI using a human-centered approach: Explainability and accuracy toward trustworthiness. IEEE Transactions on Technology and Society, 4(1), 9-23.

Seisenberger, M., ter Beek, M. H., Fan, X., Ferrari, A., Haxthausen, A. E., James, P., ... & Wimmer, S. (2022, October). Safe and secure future AI-driven railway technologies: challenges for formal methods in railway. In International Symposium on Leveraging Applications of Formal Methods (pp. 246-268). Cham: Springer Nature Switzerland.

Shen, X., Jiang, H., Chen, Y., Wang, B., & Gao, L. (2023). Pldp-fl: Federated learning with personalized local differential privacy. Entropy, 25(3), 485.

Stanford University. (2024). Artificial Intelligence Index Report. Stanford University.

Süße, T., Kobert, M., & Kries, C. (2021). Antecedents of constructive human-AI collaboration: an exploration of human actors' key competencies. In Smart and Sustainable Collaborative Networks 4.0: 22nd IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2021, Saint-Étienne, France, November 22–24, 2021, Proceedings 22 (pp. 113-124). Springer International Publishing.

Taudien, A., Fügener, A., Gupta, A. K., & Ketter, W. (2022). The effect of ai advice on human confidence in decision-making. Proceedings of the Annual Hawaii International Conference on System Sciences.

Tenopir, C., Rice, N. M., Allard, S., Baird, L., Borycz, J., Christian, L., ... & Sandusky, R. J. (2020). Data sharing, management, use, and reuse: Practices and perceptions of scientists worldwide. PloS one, 15(3), e0229003.

Thiebes, S., Lins, S., & Sunyaev, A. (2021). Trustworthy artificial intelligence. Electronic Markets, 31, 447-464.

Ulnicane, I., Knight, W., Leach, T., Stahl, B. C., & Wanjiku, W. G. (2021). Framing governance for a contested emerging technology: insights from AI policy. Policy and Society, 40(2), 158-177.

Wang, Z., Fu, D., & Zhang, J. (2023, March). Logistics data sharing method based on federated learning. In Fifth International Conference on Computer Information Science and Artificial Intelligence (CISAI 2022) (Vol. 12566, pp. 380-385). SPIE.

Wang, C., & Zhao, J. (2023). Based on human-like variable admittance control for human–robot collaborative motion. Robotica, 41(7), 2155-2176.

Weitz, K., Schiller, D., Schlagowski, R., Huber, T., & André, E. (2021). "Let me explain!": exploring the potential of virtual agents in explainable AI interaction design. Journal on Multimodal User Interfaces, 15(2), 87-98.

Xu, Z. (2022). The influence of robot-assisted industry using deep learning on the economic growth rate of manufacturing industry in the era of artificial intelligence. Wireless Communications and Mobile Computing, 2022.

Theme Development Workshops - Reports

- **TDW Public:** AI in the Public Sector - 09/2021 Aimed at implementing Trustworthy AI systems and services in public administration

  https://tailor-network.eu/wp-content/uploads/2021/11/Tailor_TDW_Public-Sector_report.pdf
- **TDW Mobility:** Future Mobility – Value of Data and Trust in AI - 10/2021- Delved into data and trust issues in AI applications for future mobility.

  https://tailor-network.eu/wp-content/uploads/2022/02/Theme-Development-Workshop-Future-Mobility-final-report.pdf
- **TDW Health:** AI for Future Healthcare - 12/2021 - Explored AI applications in healthcare, emphasising Trustworthy AI to support personalised treatment.

  https://tailor-network.eu/wp-content/uploads/2022/02/Theme-Development-Workshop-AI-for-Future-Healthcare_final-report-.pdf
- **1st cross-cutting TDW:** AI: Mitigating Bias & Disinformation **-** 05/2022 - Addressed issues related to bias and disinformation in AI.

  https://www.vision4ai.eu/wp-content/uploads/2023/01/Report-on-the-key-findings-from-the-Theme-Development-Workshop-_AI_-Mitigating-Bias-Disinformation.pdf
- **TDW Manufacturing:** AI for Future Manufacturing - 05/2022 - Discussed the integration of AI in manufacturing, concentrated on identifying common goals between academia and industry.

  https://www.vision4ai.eu/wp-content/uploads/2023/01/Report-on-the-key-findings-from-the-Theme-Development-Workshop-AI-for-Future-Manufacturing-2-1.pdf
- **TDW Energy:** AI for Future Energy & Sustainability - 02/2023 - Aimed at exploring AI applications for sustainability and energy efficiency.

  https://www.vision4ai.eu/wp-content/uploads/2023/06/Full-Report-on-the-key-findings-from-TDW_AI-for-Future-Energy_Sustainability.pdf
- **2nd cross-cutting TDW:** Trusted AI – The Future of Creating Ethical & Responsible AI - 09/2023 - Focused on developing ethical and responsible AI practices.

  https://www.vision4ai.eu/wp-content/uploads/2024/04/Full-Report-on-the-key-findings-from-the-Theme-Development-Workshop-Trusted-AI_-The-Future-of-Creating-Ethical-Responsible-AI-Systems_-1.pdf

Appendix B: Report - Best Practices for Academic and Industrial collaboration

Value and Impact through Synergy, Interaction and cooperation of Networks of AI Excellence Centres

GRANT AGREEMENT NUMBER: 952070

Academic-Industry Collaboration Best Practices

Table of contents

Acknowledgements

*The authors would like to thank the following people for their contributions to the **Cross-network Working Group on Academic-Industry Collaboration** and to this report. From **AI4Media:** Filareti Tsalakanidou (CERTH) and Danae Tsabouraki (ATC), from **HumanE-AI-Net:** Paul Lukowicz (DFKI) and Andreas Keilhacker (German Entrepreneurship), from **TAILOR:** Janina Hoppstader (DFKI) and Kyra Kiefer (DFKI), from **ELISE:** Christopher Murray (AALTO) and Bernhard Nessler (Johannes Kepler Universitat Linz), from **ELSA:** Lorraine Wolter (CISPA) and Mario Fritz (CISPA), from **euRobin:** Alessandro Settimi (U. Pisa) and Christophe Leroux (CEA). Without their input, transparency, and their availability for interviews and exchanges via email, this report would not have been possible.*

Introduction

The **Cross-network Working Group on Academic-Industry Collaboration** was established in 2022 to facilitate discussions and share best practices between the Networks of Excellences (hereafter referred to as NoEs) of the ICT-48 calls of the Horizon Europe programme. This working group consists of the four original NoEs (AI4Media, Humane-AI-Net, ELISE, and TAILOR) who will reach project completion in summer 2024, as well as two more recent projects (euRobin and ELSA) who were both nearly halfway through their projects as of publication of this report (Q1 2024).

Through the creation of this working group, the VISION project has, from a cross network perspective, coordinated and supported efforts to maximise innovation potential through academic and industry collaboration. This facilitation includes three primary activities:

- sharing best practices to support innovation and transfer of AI technology in the NoEs with a particular focus on the on-demand-platform (this report) ;
- scouting for novel ideas and technology with industrial and societal relevance ;
- support their integration and alignment with strategic roadmaps of the NoEs and the Adra SRIDA (see https://www.vision4ai.eu/sra/).

All projects have intentional **interaction and collaboration between academia and industry** which takes many forms. Typically, collaboration has been achieved through industrial partners directly involved in the project as full project partners, through open calls, workshops, or via existing relationships in an advisory capacity. This report provides further details on success stories to share with regards to collaboration between academia and industry, as well as recommendations, challenges, and outlooks to the future.

Methodology

A combination of physical meetings, online group discussions, individual interviews, and electronic communication (a mailing list and collaborative online documents), as well as publicly available documents (deliverables, articles, reports) from the NoEs were used to gather input to develop this report. Following three online meetings, the VISION project analysed the inputs from these meetings to develop a working document which outlined the common activities, challenges and recommendations.

This working document and a suggested calendar were then shared with the representatives of the NoEs at a physical session at the **3rd ICT-48 Community workshop** on June 7, 2023 in Siena, Italy. Two additional physical meetings took place in July 2024 (the SRIDA and SRA workshops in Brussels, Belgium on 4-5 July 2023) to ensure support of industry-research collaboration and sufficient alignment between research and innovation. Individual interviews with each of the projects (typically the project coordinator, the partner responsible for the industry-related work packages or activities, or both) were carried out with VISION partners **Inria** (responsible for this best practice activity) and **Intellera** (responsible for EDIH collaboration with NoEs).

The topics addressed during the interviews make up the bulk of the following sections and included questions related to methodology and processes established during proposal writing and during the project itself, interactions with industry, project activities with industry partners and success stories, challenges encountered and their mitigation, and recommendations for future projects including integration to the AI-on-Demand platform.

Categorization of project activities with Industrial collaboration

While European Research & Innovation projects are all of course unique, with their special *"je ne sais quoi"* that makes them stand out in a highly competitive arena, there are naturally common activities to them all. Some of these may be more obvious than others (dissemination & communication activities, project management…), however project collaboration between academia and industry within R&I projects can often take on similar characteristics.

The activities related to industrial collaboration within the **Networks of Excellence** can be organised into **5 main categories:**

- **Testing and validation**[2]: which may take the shape of co-created use cases, hackathons, or industrial challenges
- **Financial support**: including cascade funding, microprojects, open calls, prizes, awards, or connectivity funds
- **Social interaction and networking**: including physical or online events such as conferences, workshops and panel discussions
- **Education**[3]**:** such as industry oriented PhD programmes, mobility funds, and industry tracks
- **Support to the R&I Ecosystem:** through the development or use of existing platforms, contribution to industrial roadmaps and Strategic Research Agendas, collaboration with existing networks

When it came to including industrial partners in Horizon Europe R&I projects, all of the NoEs designed **specific tasks or work packages** into the project work plan during proposal writing to specify how industrial partners would contribute to the project. This included industrial partners as full project partners, for example as leaders of use case development (often with an industrial partner and a research partner working in pairs) or contributors to tasks aiming to align industrial needs with EU research. The following sections describe the activities within the main categories described above, with a focus on success stories, followed by challenges and recommendations encountered during the project lifetime.

Testing and Validation

Use cases, hackathons, and industrial challenges were common activities to each of the NoE projects. The role of industry partners could be as that of a technology provider or as an end user. In the majority of NoEs, the industry sectors of the application domains were varied, including:

- Mobility (autonomous driving)
- Robotics and manufacturing
- Multimedia
- Cybersecurity

[2] The research objectives and technical components of the testing and validation activities of the NoEs have been covered in detail in project deliverables and publicly available reports. In this report, we will consider only the best practices related to industrial partner involvement in these activities.

[3] Similarly, the activities related to Education and training will only be considered in this report through the lens of their inclusion and involvement of industrial partners. As such, activities such as Summer Schools and AIDA, will not be mentioned in detail even though their results were very significant. As Education and training related activities in the context of industrial collaboration tend to include an element of financial support, it will be included in this section of the report and not treated as a separate category.

- Energy
- Smart industry
- Healthcare
- IT software and services
- Public sector

A notable exception is in the case of AI4Media where the focus was on one sole industry: media (focusing, however, on different media industry sectors, including news, journalism, music, games, audiovisual archives, etc.). For a complete list of testing and validation activities carried out in the context of the NoE project activities, see Appendix I.

Challenges

Processes take time.

While it is crucial to clarify processes and ways of communicating at the beginning of the project, projects can easily fall behind schedule while setting everything up and this can be discouraging to everyone involved. Take the time needed to operationalize communication at the project level at the beginning, but be aware that taking too much time may result in missing important first deadlines. To mitigate this, include **operationalization planning in the project implementation plan** during proposal writing. When appropriate, adapt existing processes to fit your project.

Data and IP protection can be a major hurdle.

Industry involvement in R&I projects tends to stall due to **issues of data and IP protection**. This is a potential issue that should be considered from the very beginning of any collaboration as if it is not resolved it can block a project before it even starts. Be proactive, open and transparent and work together to find solutions.

Reach out to those outside of the existing R&I network.

Some of the NoEs highlighted that it was **not easy to get industry representatives from outside of the typical R&I network involved** in their project activities. Calls to action (even when disseminated through multiple outlets) and open workshops were not very successful, so further reflection is needed for how to better engage with "new" actors.

Consider existing roadblocks to participation.

Formal (administrative) roadblocks as well as a lack of resources (i.e., available man months) make it difficult for start-ups and SMEs to participate. To mitigate this, **easing bureaucratic overhead for start-ups and SMEs to participate** in projects would make a big difference. Another solution could be paid pilots as this would ease the resources needed to participate.

Recommendations

Build on existing relationships.

The inclusion of **industrial partners that have previously worked with academic or research partners** and with whom a relationship of trust has already been established can help jump start activities at the beginning of a project. **Be clear** with partners about what is expected during project duration, not only in terms of content but also their implication in the process, i.e., the timeline, expected resources (man hours and expertise), and what should be delivered. These early adopters can also help facilitate the involvement of other industrial partners who may not have been directly involved in the project from the beginning.

Be selective: define your criteria to include industry partners.

The industry partners involved in AI4Media for example, were **selected** on the basis of the four main criteria: industry profile, excellence in their area of expertise, relevance to project activities, previous

experience / participation in EC-funded projects, and previous relationships and collaboration with other project partners.

Explore all avenues to reach new partners.

Disseminate information about public workshops and consultations through as many avenues as possible to engage with new contacts / organisations not directly involved in the EU research world.

Aim for balanced partner representation.

By including partners from research, industry, and the social sciences & humanities, the same issue can be addressed from different angles. Consideration must also be given to the **role an industrial partner could play** in a consortium i.e., as a technology provider or as an end user as this will inevitably imply different research needs.

Allow interaction to happen organically.

The European research world tends to be small, and often its major actors are already working together. Rather than forcing these interactions to happen in each project, they should be allowed to **happen organically** as much as possible. When it is necessary to "force" collaboration, such as the current need related to Generative AI and Large Language Models (LLMs), support from the European Commission would be very beneficial. Once the EU has formally supported a research topic, all networks will be encouraged to get behind the initiative.

Financial support to industry collaboration

Open calls

In part due to the difficulty for SMEs and start-ups to contribute meaningfully to a 3–4 year research projects, a trend in the current Horizon Europe Framework Programme has been to set aside a specific amount within the project budget for **financial support**, be it through **dedicated funding for short-term projects with specific objectives** (often called micro-projects, open calls, or cascade funding) as well as **dedicated funding for exchanges** (onsite) through what is often called mobility or connectivity funds.

The ELISE, ELSA, and euRobin projects developed open calls available to SMEs and start-ups, with the winners carrying out their research over 6 months and receiving 60 000 € (ELISE, euRobin, ELSA). As ELISE and ELSA are part of the ELLIS network, one of the conditions of their open call is the inclusion of a scientific advisor from the ELLIS network. HumanE-AI-Net funded micro-projects which ran for 2-6 months; a main difference to their approach is that micro-projects must include at least 2 partners and at least one of those partners should be an existing project partner. The project partners were also encouraged to apply with at least one external partner. The open calls developed by AI4Media were open to SMEs and Midcaps as well as academia and research organisations, with projects lasting 9 or 12 months and winners receiving up to 50 000 €. Applicants had to choose between a research track (12-month projects) or an application track (9-month projects) and were also supported and coached by a mentor coming from the AI4Media consortium.

Due to the funding set aside in the projects and how the open calls were set up, the total number of projects funded varied considerably by project; for example, HumanE-AI-Net financed over 100 microprojects, ELISE funded 2 opens calls with 16 selected projects, ELSA provided support to 6 SMEs in the first open call, and AI4Media held two open calls with 10 projects selected per call (5 Research and 5 Application track).

The **open calls** and the projects they financed were overall very **successful** with tangible and transferable advances to the AI domain and significant contributions to the European AI ecosystem.

They were also highly competitive, with dozens if not hundreds of quality applications submitted for a limited number of spots. For example, 155 applications were submitted in the two open calls of AI4Media and 20 projects were selected for funding.

Mobility and exchange programs

While many of the mobility and exchange programs developed in the NoEs focused on exchanges between research institutions and universities, it was also possible for young students, PhD and postdocs to use this funding for an **industry placement**. Typically, these programs facilitated on-site research visits or participation in conferences, to help young researchers gain experience and bring in expertise from outside the project networks. These programs included:

- **AI4Media:** Junior Fellows Exchange Program[4] (https://www.ai4media.eu/junior-fellows-program/)
- **TAILOR:** Connectivity Fund
- **ELISE:** PhD and postdoc program
- **ELSA:** Mobility programs
- **HumanE-AI-Net:** industrial Ph.D. postdoc and internship program
- **euRobin:** Industrial internships for PhD students

Challenges

Scalability and size of projects.

The main issue for SMEs and start-ups is **available resources**, i.e. they need to be able to pay man months for researchers to contribute to open calls or microprojects. It tends to be easier for research organisations to find the resources as they are already working on certain topics and have resources readily available. For industry to contribute at a higher level, the projects would need to be larger (more than 60 000 € over 6 months) to cover the man months necessary, but not as large as multiyear large scale European collaborative projects where resources can get bogged down in administrative burdens. Further reflection on a **middle ground and the right formula** is still needed.

Legal obligations cannot be overlooked.

While not as administratively heavy as a full partnership in a European project, there are still **legal obligations and declarations** needed for open calls, microprojects, and to a lesser extent, reimbursements for travel costs related to mobility projects. Planning buffer periods and anticipating extra time for unforeseen issues or emergencies should be taken into account during the funding rounds and expected start dates.

Travel restrictions.

As mentioned above, some of the mobility programs and connectivity funds for travel between institutions have been met with varying degrees of success due to the **Covid-19 pandemic**. While travel did pick up during the second half of the NoE projects, it took even more time to get people used to travelling again. Overall, these programs were not as frequently used as anticipated during proposal writing.

[4] As of publication (Q1 2024) the AI4Media Junior Fellows Exchange Program has received 83 applications including 38 internal (between AI4Media partners), 45 external (collaboration with third parties), **11 with industry,** 71 between academic/research institutions, 1 other, and consisting of 23 female and 60 male Junior fellows.

Recommendations

Leverage on existing synergies.

In the case of microprojects between two or more partners, this is a good opportunity for research organisations and industrial partners to **leverage on existing synergies** or build on projects they were already undertaking. Rather than starting something from scratch, think about what projects are already underway and how they could be supplemented or improved by additional funding from outside resources.

Don't forget other sources of funding.

The funding from an open call or mobility programme within an existing European project can not only be helpful to move an existing project forward, but also can be **combined with other sources of funding.** Applicants should investigate other sources such as local, regional or national initiatives, other European initiatives, all while ensuring double funding for the same activity does not take place.

Favour real interactions and frequent collaboration.

While the COVID-19 pandemic made physical collaboration and travel difficult at the beginning of the NoE projects, in order for mobility programmes and even micro-projects to be successful, it is crucial for there to be **frequent interaction between the partners** and hosting institutions. This can take place through different formats, such as Face to Face meetings, workshops, posters, or informal exchanges, and exchanges can be physical, virtual or hybrid.

Consider including a project partner specialised in open calls.

The AI4Media, ELSA and euRobin projects have included an **external partner specialised in the management of open calls** to carry out these activities within their projects. ELISE made the decision to do everything in-house at the coordinator's institution which was written into their work plan.

Social interactions and networking

When the NoEs were asked what they would consider to be a project success story, a number of them cited creating opportunities for all partners and interested stakeholders to meet, often in the form of a **workshop**. Workshops are ideal opportunities to **facilitate discussions** between academic and industrial partners who are both internal and external to R&I projects. Traditionally, in previous framework programmes, a "typical" EU R&I project workshop would have been written into a project proposal as a mid-project or end of year project milestone, and these workshops would bring together anywhere from 50 to 200 stakeholders at a major European city to highlight project achievements and future sustainability plans. While these project workshops could and should be considered successful project achievements and an opportunity to highlight successful technical progress, they did not typically allow for exchanges or in-depth discussions between academic and industrial partners.

To close this capability gap, the format in recent years has changed, including **co-creation with academic and industrial partner**s, and with a focus on **long term strategy and trends**. They also frequently take place online or in a hybrid format. This was originally due to necessity due to the COVID-19 pandemic, and while travel within Europe became possible about halfway through the NoE project lifecycles, online workshops have continued to be organised with much success. The format of collaborative workshops organised by NoEs have taken on different formats, notably:

- **Mini workshops** of no more than 10 to 20 people to facilitate a co-creation process with both industry and technical partners in attendance

- **Theme Development Workshops (TDWs):** where current hot topics in the field of AI (healthcare, manufacturing, energy) were discussed during an all-day online session, including keynote speeches and breakout sessions
- **Speculative workshops:** invite use case partners and technical partners to attend a workshop to come up with potential illustrative scenarios of new technologies or algorithms, if it is not possible to test them all in existing Use Cases.

Challenges

Marketing is crucial.

The European ecosystem has a myriad of online, hybrid and physical events happening every day and **marketing your event** to the right people is an art in itself. Start early, reach out using multiple communication channels and networks, and figure out how to make it attractive to the people you are trying to reach. Working with dissemination, communication and marketing experts is key.

Getting the right representative balance.

When brainstorming the objectives and agenda for workshops there are always a lot of ideas of topics and participants to be included. It is difficult to find the right balance between research and industry, applications, priorities, and profiles. It takes time to review, discuss, and make decisions. When it comes to industry profiles, large industry tends to have more resources available to get involved in these types of events and it was **harder to convince SMEs, start-ups and even the public sector to find the time**; not only to attend but also to participate in the planning and organisation of the event.

Finding common ground on short/mid/ and long-term priorities.

Workshops are an opportunity to move outside of the short-term priorities of collaborative research projects, and it is important to remember that industry is more interested in long-term trends than short-term advances. The **mid-term perspective** is also frequently missing from these discussions and should be taken into account. If all three perspectives are not included, industry representatives may be sceptical to attend or not see the interest that such an event can have for them.

Recommendations

Preparation is everything.

The preparation phase of workshops can be the most difficult; be sure to begin planning early and allow ample time for the follow-up. By planning early, the organisation committee will have enough time to ensure equal representation of industry and academic partners, as well as the right speaker profiles. Spending adequate time on preparation also ensures that the theme and topics are well considered; that they are appealing, digestible, and not too broad of a scope. **Co-organizing with both industry and academic partners** helps ensure the facilitation and exchanges of ideas and expertise as well as a broad representation of different profiles at the meeting, thanks to professional networks.

Consider the proper format for the objectives you wish to achieve.

While the online format was first utilised out of necessity, it proved very successful in particular for the TDWs. **Online workshops** can allow high level speakers to attend more easily, even if they are only able to give a short speech and then disconnect, and **representation can be broader** when participants are able to connect online. However, for **smaller groups** and more in-depth discussions (i.e., mini-workshops of just 10-20 people), **physical meetings** may be more effective.

Promote interdisciplinarity aspects when relevant.

The current trend at workshops tends to be the analysis of technical aspects of Artificial Intelligence. However, in larger events where there can be more room for different points of view or parallel

sessions, it is beneficial to include other areas of expertise including legal / ethical / societal aspects and inviting relevant experts to join the discussion.

Keep it social, especially at the beginning.

Find opportunities for partners to meet: poster sessions at consortium meetings, demonstrations, evaluation phases… **Workshops** are easily digestible and it is the simplest way to get industry and research to come together. While social formats tend to work best, **hackathons** have also had a lot of success, notably for HumanE-AI-Net, even if they are more technical than social. The ELSA project agreed that success stories in the first year of the project were mainly related to networking and bringing research & industry partners together; **General Assemblies, poster sessions, workshops, town hall meetings** and **surveys.**

Support to the R&I ecosystem

Finally, a number of activities dedicated to the strengthening of the Research and Innovation ecosystem through the inclusion of the industry perspective were carried out during the course of the NoE projects. This included, but is not limited to: contributions to the Strategic Research Agendas (SRA) of each of the NoEs as well as Adra's Joint Strategic Research Innovation and Development Agenda 2025-2027 (SRIDA); collaborations with existing networks, NoEs, and initiatives, use or deployment or existing platforms and more specifically the AI-on-Demand Platform.

Contribution to Strategic Research Agendas and inclusion of Industry roadmaps

All of the NoEs attended the SRIDA and SRA workshops in Brussels, Belgium on 4-5 July 2023 to ensure support of industry-research collaboration and sufficient alignment between research and innovation. Break-out sessions during the TDWs were organised by TAILOR in collaboration with other NoEs to **discuss research agendas and included industry output to the roadmap working groups**. Overall, industry partners seem to be primarily interested in the **data and legal issues** surrounding data and how it would be included in research agendas. Finally, projects pulled from reports on use cases written by industry and research partners together (ELSA), as well as on the publication of white papers written from the industry perspective (AI4Media) to ensure alignment between AI research and media industry needs.

Collaboration with relevant networks

The projects were able to rely on existing networks, other NoEs, and the VISION project to reach out to extended networks, particularly for dissemination purposes. Having a unique point of contact through VISION helped in terms of numbers reached as well as having a unique point of entry for AI. This is equally true for Adra as a unique point of entry for AI, Data and Robotics. Similarly, some of the NoEs were able to **capitalise on existing networks** such as IRCIIM or euRobotics for euRobin, ELLIS for the ELSA, ELISE and ELIAS lighthouses, or CLAIRE for TAILOR. By building activities into the projects that strengthen the network, this ensures strategic alignment at a large scale as well as the involvement of industrial partners from inception.

Collaboration with European Digital Innovation Hubs (EDIHs)

The interviews with NoEs included specific questions to delve deeper into practical collaboration activities between NoEs and (European) Digital Innovation Hubs ((E)DIHs). According to the four original NoEs, (E)DIHs were **hard to engage with** since the beginning of the project mainly due to the timing of funding opportunities and concrete incentives to collaborate. According to one NoE, when engaging with DIHs, there was a general lack of information about what the Networks were and how

they operated. More specifically, according to some DIHs, NoEs represented too high-level stakeholders focused on research and strategic topics in the field of AI rather than on industry-oriented outputs. One of the problems cited was related to the lack of funding for DIHs to participate in workshops or meetings involving NoEs, as they could not fully grasp their utility.

Nevertheless, aware of the challenges in fostering collaboration among these actors within the European AI ecosystem of excellence, these interviews were a useful opportunity to continue raising awareness especially with the "new" NoEs on potential collaboration opportunities with DIHs, emphasising the importance of connecting these entities to enhance knowledge transfer and sector-specific expertise. Indeed, **recently established NoEs** are in the process of **planning their collaboration activities with DIHs**. For example, ELSA representatives participated in an event hosted by a European Digital Innovation Hub on trustworthy AI and the transfer of AI knowledge towards regional companies.

The AI-on-Demand Platform

Most of the NoEs interviewed recognized the importance of the AI-on-Demand platform as a one-stop shop for everything AI made in Europe. During the course of the project, many of the projects utilised it as an open access repository to publish their results and reports and to engage with the community.

Challenges

Translating industrial priorities to the research agenda.

It is no secret that industry partners do not, on average, contribute equally to the projects (typically there are more research or academic partners in a research project than there are industrial partners). Therefore, industry partners want to ensure that their outcomes will contribute to the research agenda. At the same time, company priorities can make this difficult as a low TRL product is only interesting to a certain kind of industrial company.

The easiest interactions remained high level.

Sometimes it was easier for projects to communicate at the higher level, i.e., for issues related to project management or communication activities, than to interact at the industry level as not all NoEs were targeting the same industry or working in the same research domains.

Don't forget outside competitors.

As AI-on-Demand is still under development, it remains to be seen what capabilities and services will be reached over time. However, one cannot ignore the fact that it will be difficult to compete with existing open-source repositories such as GitHub.

Planning and monitoring are crucial.

Managing collaborations within individual networks, comprising 30+ partners, and coordinating internal network activities is a complex task that poses inherent challenges. In this context, collaboration among different NoEs has certainly enriched the AI ecosystem of excellence, while, at the same time, adding another layer to this complexity. Beyond this, according to several NoE representatives, engaging with EDIHs introduced an additional tier that **demands extra resources and effort**. That is why, it is fundamental to plan this collaboration from the beginning of the project and eventually add specific KPIs to monitor its effective realisation.

There are other ways to reach the market.

"Collaboration cannot be forced". This was mentioned several times during the interviews. NoEs and their representatives often found it **easier to reach out to SMEs or start-ups** directly rather than passing through (E)DIHs. Often, engaging directly with these realities has been easier than

collaborating with the Hubs. This poses inherent challenges to the role of (E)DIHs as mediators between research and industry. In this context, EDIHs should find the correct incentives to connect to the Networks in order to find the most up to date knowledge and expertise to be shared with their clients.

Recommendations

Related to the EDIHs

Earmark funding and indicate specific KPI.

Unless there are **specific indications and requirements within Grant Agreements**, DIHs and individual NoEs have few available resources and concrete incentives to establish connections and develop collaborative activities. Therefore, if the Commission wishes to foster this direct link in the future, then the specific Calls involving DIHs, NoEs and TEFs should emphasise the importance of this link and concrete actions to be developed between all the stakeholders that are part of the European Ecosystem of Excellence.

Publicise successful collaborations.

Establishing the correct channels right from the project's outset ensures a seamless and structured collaboration, setting the foundations for successful partnerships between NoEs and EDIHs. For example, **creating awareness within consortia** about planned and ongoing collaborations or opportunities can help break down silos and incentivise different stakeholders to act in a similar way. It would be useful to find ways to **align incentives** for both researchers and DIHs to encourage sustained collaboration. This could involve external recognition and/or rewarding of successful partnerships or contributions to digitization efforts. **Showcasing successful collaborations** as case studies to inspire and guide other research institutions and DIHs by highlighting tangible outcomes can also motivate stakeholders to invest in similar collaborations.

Set up events with a specific focus on SMEs/Start-ups, DIHs and AI research

Setting up workshops with real case studies can provide a practical understanding of the possibilities of collaboration between these two realities or of the hurdles which currently hamper it. Smaller "TDW" initiatives could be suggested to the Digital Transformation Accelerator (DTA) or to the Testing and Experimentation Facilities (TEF) Coordination Action to **exchange knowledge with EDIHs on the world of scientific research in AI** and foster the sharing of insights on this topic and broader connections. Involving DIHs in events organised to share research findings, discuss use cases, and disseminate industry-oriented research results in the field of AI can help increase awareness and interest in collaborations.

Choose the right people.

Among the plethora of actors typically involved in these projects, identifying **individuals working in interconnected projects** is recognized as a valuable factor in bridging gaps between these two realities. Often, one institution is involved both in academic research and in (E)DIHs without a mutual understanding or dissemination of relevant scientific knowledge. Individuals appointed to work with (E)DIHs (especially if coming from universities or research centres) should also be actively involved in research and/or contributing to the work of the NoEs so that meaningful connections are easily created.

Use the AIOD platform for networking and communication.

The AIOD should be the **go-to platform to enhance networking and encourage increased communication** among research institutions and DIHs. Enhancing collaboration between NoEs and EDIHs requires a focus on efficient communication and dissemination. The platform should be used to

facilitate continuous interactions between research institutions and DIHs, e.g. through regular updates, newsletters, or dedicated channels where both parties can share opportunities and challenges in collaboration.

Related to Strategic Research Agendas and Industrial Roadmaps.

For future iterations of research agendas, consider other avenues to reach industrial partners that are outside of the projects, for example a public consultation process, inclusion of white papers written by industry, or open surveys.

Related to existing networks.

The main added value of existing networks and VISION was to disseminate upcoming activities or events and to get people involved outside of the project networks.

Related to the AI-On-Demand platform.

Consider what services or propositions will be offered in addition to the repository (possibilities mentioned included as a marketplace, benchmarking, supportive reporting,…), NoEs mentioned that the AI4Experiments service is very useful as this is something that does not exist elsewhere, and also that they would like to use the platform to publish future open calls for financial support. Finally, ensuring interoperability with projects and their existing services and platforms is crucial to the AI-on-Demand's success.

Lessons learned

In the previous sections recommendations and challenges have been given for each category of activities. Below, lessons learned and recommendations that are globally relevant have been detailed.

Meet industry partners where their interests lie.

Industry tends to be interested in the long term; i.e., where is the journey going, what are the next trends, and how do we get there. Creating a single product through the implementation of a 3-year project is not necessarily their highest priority. It is therefore crucial to meet industry partners where their interests and research objectives converge, rather than pushing forward an agenda that is not compatible.

Don't reinvent the wheel.

Rather than developing processes that are project specific, pull from the experience of your partners and coordinators and adapt existing methodologies for your needs. Making these processes available and easily adaptable via a platform such as AI-on-Demand would be effective.

There is no "blank page".

All R&I projects have to compromise between what the partners are already working on within their institutions and needs defined by the industry. There is no such thing as starting from scratch. Project partners should consider existing gaps between researchers and end users from the very beginning (i.e., during proposal writing) rather than waiting until the project has gotten up and running to discover where the gaps are.

Active involvement is needed for success.

Effective involvement of industry partners requires active investment in the project. Be sure you have appropriate project management resources to manage partner involvement in addition to "regular" project management tasks. Similarly, if some partners are less active than others it can create an uneven dynamic. Getting everyone involved from the beginning of the project, and being sure to deliver to industry partners what was promised during proposal writing will help empower all partners to take ownership of the results and get effectively involved.

Conclusions and looking to the future

Each of the four original NoEs, whose projects will reach completion in summer 2024, were asked during their individual interviews what they consider to be a success story of their project and what activities could be sustainable or easily replicable by future projects. The responses tended to be similar; many cited mini projects and open calls as very successful ways to interact with industry on specific, targeted research objectives for a limited amount of time with a dedicated budget to provide personnel resources and on-site travel. Now that the processes have been established for submission, evaluation, and selection, future projects can easily replicate what has been done in previous projects with adaptations relevant for their specific needs. The AI-on-demand platform is an ideal place to host this information as well as online submissions for future open calls. Of the social formats, the Theme Development Workshops were mentioned many times as successful stand-alone events, with the potential to be replicated as originally designed or with variations (for example deep-dive TDWs which would take place with smaller groups and in person, or as a “mini TDW” for an industry partner who has requested further discussion on a specific topic.

The two main issues for sustainability are resources and funding which have to be available over the long-term. This is why long-term relationships between academia and industry are so crucial, as getting research to market does not happen within the timeline of a 3-to-4-year research project. Long-term collaboration is necessary. At the same time the activities carried out during the NoE project lifetimes have facilitated discussions, developed results and technological advances on specific use cases over short periods of time, and contributed to the strengthening of existing and new relationships between academic and industrial partners.

Appendix I: List of Academia and Industry transfer activities by project

Website: https://www.ai4media.eu/

Co-creation of use cases (demonstrators)

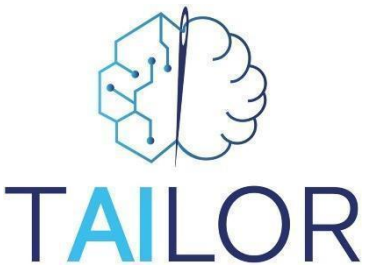
Network of Associate Members

AI4Media Open Calls for SMEs

Research Exchanges

White papers

Contribution to the Strategic Research Agenda



Website: https://tailor-network.eu/

Use cases and showcases

Theme Development Workshops

Hackathons and Industrial Challenges

Contribution to the Strategic Research Agenda

Connectivity Fund

Website: https://www.elise-ai.eu/

ELLIS PhD & Postdoc Programme + Industry track

Cascade funding: open calls for SMEs or Startups

Contribution to the Strategic Research Agenda

Catalogue of AI Centers

Website: https://www.humane-ai.eu/

Microprojects

Matchmaking events

Hackathons

Industrial use cases

Website: https://www.elsa-ai.eu/

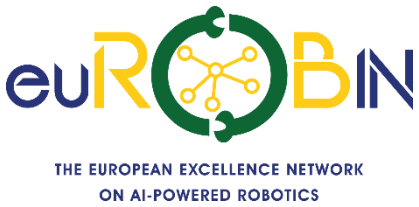
Use Cases

Grand Challenges

Contribution to the Strategic Research Agenda

Innovation lab including

Benchmarks Platform and Open calls for SMEs / Start-ups



Official Website: https://www.eurobin-project.eu/

Technology and career match-making

Industrial internships

Cooperative Competitions and Hackathons

Cascade funding instruments

Contribution to the Strategic Research Agenda