AI CUBE

ARTIFICIAL INTELLIGENCE AND BIG DATA CSA FOR PROCESS INDUSTRY USERS, BUSINESS DEVELOPMENT AND EXPLOITATION

AI-CUBE is coming to an end!

Since the 1st of September 2020, when the project started, all partners have worked hand-in-hand to develop and define artificial intelligence (AI) and Big Data (BD) guidelines for the 10 SPIRE industrial sectors, namely: Cement, Ceramics, Chemicals, Engineering, Minerals and ores, Non-ferrous metals, Steel, Water, Paper & Pulp and Refining. The consortium effort focused on designing and validating a consolidated roadmap, ensuring solution feasibility and benefits for the European industrial community, providing an overview of current AI and BD applications, and identifying exploitable synergies among sectors. Based on this, the project also developed a three-dimensional conceptual matrix based on AI and BD technologies, application areas and SPIRE sectors.

As the project is coming to an end, let's discover all the achievements obtained by AI-CUBE! Visit the project website and follow the project on LinkedIn and Twitter!

Current landscape analysis: AI & BD technologies and industry applications

The main objectives of the first 12 months of the project, related to WP1, were the following:

- To establish the current technological and industrial landscape regarding AI and BD technologies of European process industry sectors.
- To set the basis of the following WPs work in defining mapping tools and the roadmap for AI and BD.
- To conduct literature reviews and consultations with relevant stakeholders.
- To adjust the original implementation plan expanding it to additional macro applications areas.

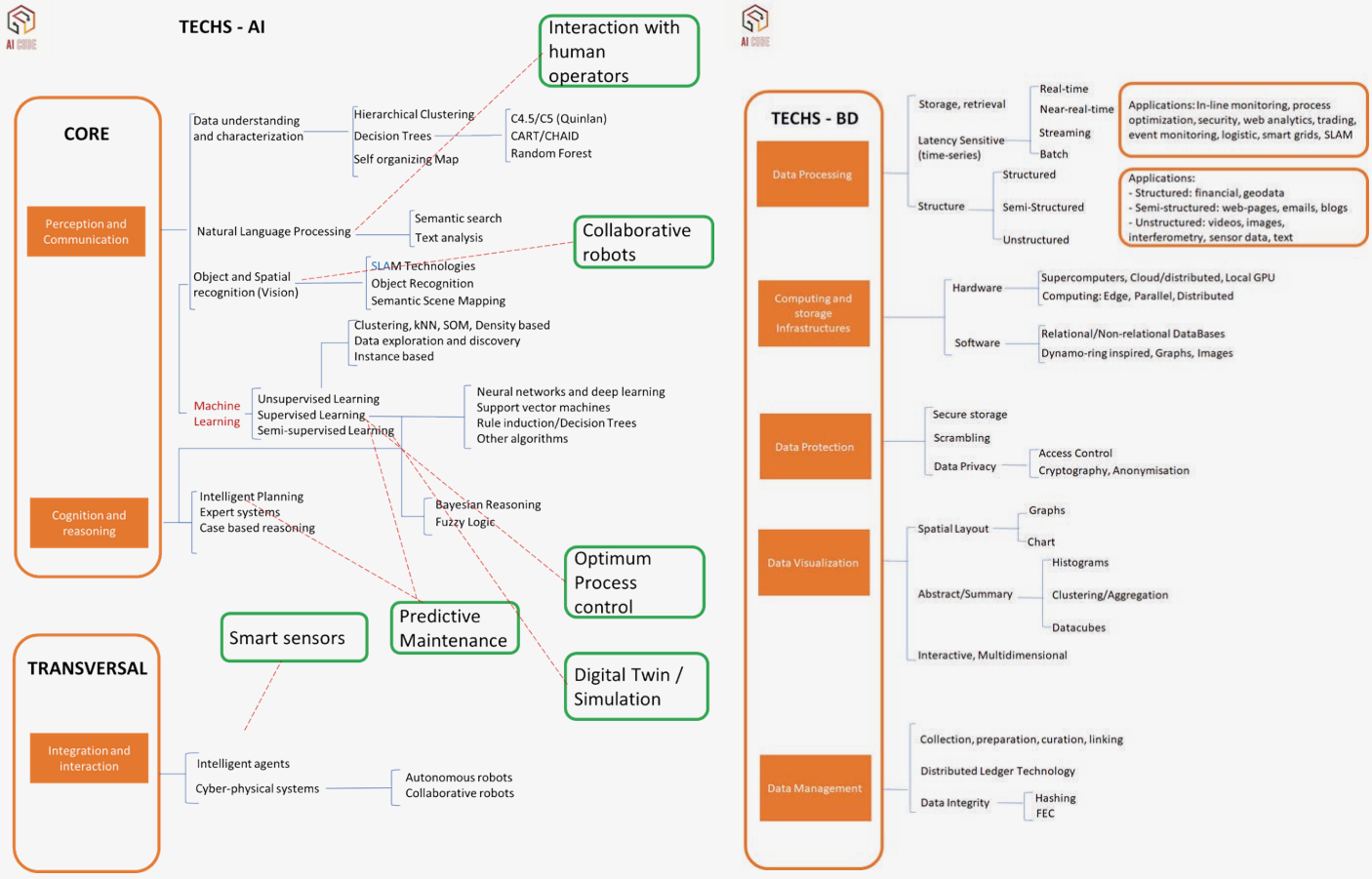


Figure 1: Taxonomies for (a) Artificial Intelligence Techniques, left and (b) Big Data Techniques, right.

A first overall description was obtained for the critical technological features, their maturity level and applicability, which served as the basis for the following work packages. Figures 1a and 1b illustrate two taxonomies developed in WP1, which consider the current state of the art taxonomies, such as the one developed by the EC AI Expert group and other taxonomies which have been customised for SPIRE and process industries of the AI-CUBE project. Figure 1a shows the top level on the left, divided into two main core categories (perception and communication,

cognition, and reasoning) and one transversal category (interaction). At the second level of the AI taxonomy, four categories are defined, one of which is transversal (machine learning). Some example applications are indicated in the green outlined text towards the right. In Figure 1b, five top-level DB categories are shown on the left, and the subcategories are mainly hardware and software related. Some examples of applications are indicated in the orange text on the top right. The taxonomy categories were then used to perform an extensive literature search to establish the state of the art, and to update the three AI-CUBE dimensions: processes, sectors and technologies.

Mapping of AI & BD technologies and maturity level assessment

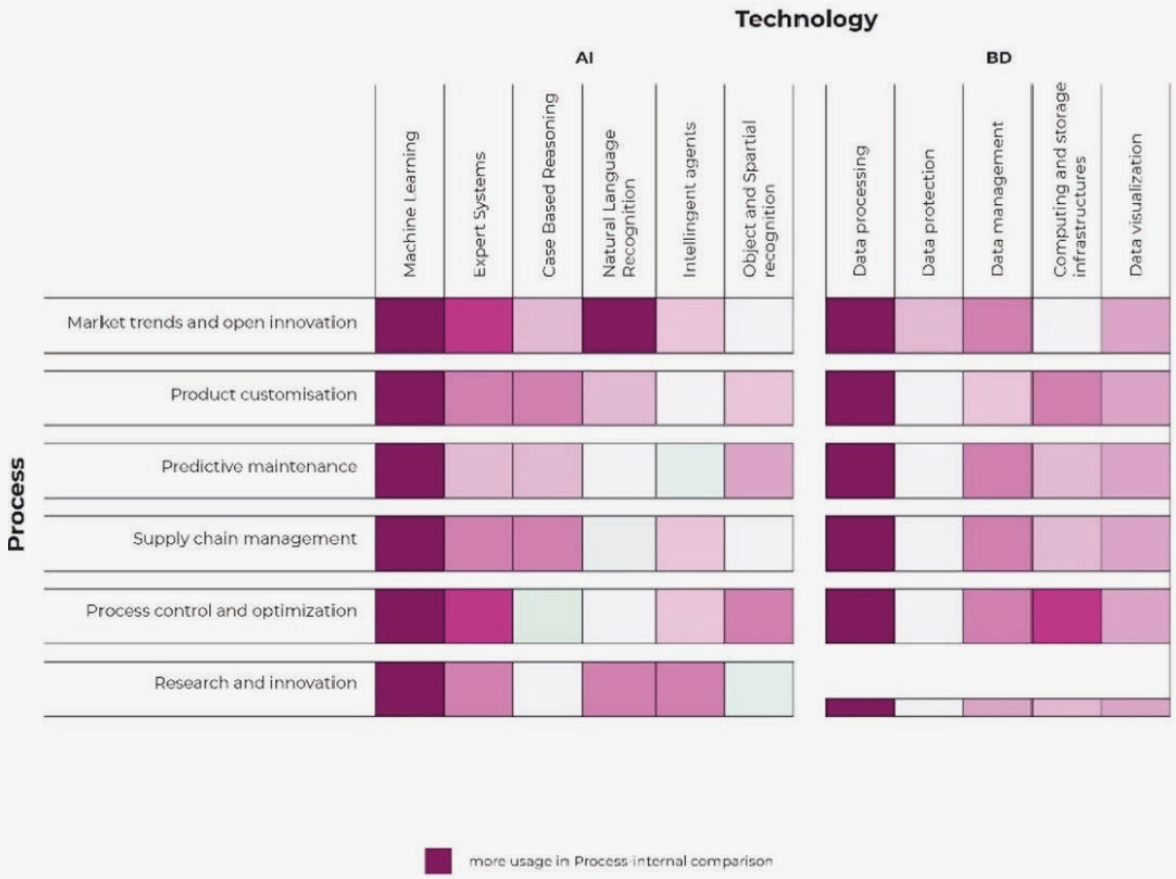
In Work package 3 of the AI-CUBE project, the project consortium focussed on the current status of AI and BD technologies in the process industry and its maturity in cooperation with experts from the industry in the form of online surveys and workshops under the WP-lead of the Fraunhofer Institute of Material Flow and Logistics (IML). Through an online survey with the participation of industrial users and technology providers, insights on current technology usage, implementation barriers, impacts, factors enabling the usage of AI and BD in the process industry, and transfer possibilities were identified and integrated into the development and transfer processes. The Maturity Model developed in WP2 was applied to the technology-sector-application area combinations identified in WP1 to assess the actual maturity levels. Through a combination of the survey results with further research insights on the current state of research on implementation processes for ML and BD, as well as existing methods and tools enabling more accessible AI and BD applications, the project team created an overall status of the process industry in terms of AI and BD maturity and transfer paths.

Targeted online communications via industry associations, newsletters, social media, and direct approaches were used to target experts from the industries under consideration, resulting in more than 100 participants in the AI-CUBE online survey. Among these participants, 56 shared concrete implementation examples that revealed specific insights and experiences. The following clustering of application areas and AI and BD technologies for the different application areas in the process industry show first insights across all sectors, underlining the impact of Machine Learning, Expert Systems and Data Processing technologies.

After the initial mapping and maturity assessments of the technologies used, sector and application area-related comparisons were carried out, revealing existing gaps and potential for increased exploitation. The most mentioned barriers of unclear business case or strategy, insufficient data quality and insufficient data access, and the lack of the needed talent also play an important role here.

By linking the current use of AI and BD technology and the maturity levels of the various sectors and application areas, cross-sectoral transfer potentials were identified, and a transfer model was formulated to increase the penetration of the process industry here as a whole. The factors enabling the implementation of AI and BD are considered within the framework of the implementation model. The barriers are addressed via the strategies presented for overcoming these challenges proactively and reactively. As a result, the guideline development prerequisites were

created for the following work packages. The results were also continuously validated and disseminated in workshops and expert interviews.



Roadmap & Industry Synergies

WP4 was executed during the second year of the AI-CUBE project with the primary objective of defining a guideline on AI and BD of application in process industries for all the SPIRE sectors with specific recommendations to guide researchers, managers and operators in the implantation of these technologies. For this and based on the results of previous work packages, a structured analysis of gaps and opportunities of AI and BD technologies was performed, allowing the identification of knowledge transfer and synergies between sectors to be exploited. The obtained AI-CUBE guidelines were validated by industry and interested stakeholders, boosting knowledge sharing among different processes and sectors.

T4.1 worked through two main themes:

i) The contribution of AI and BD solutions to the process industry to identify gaps and opportunities in the implementation of these technologies

ii) Identifying the main business trends resulting from implementing AI and BD technologies in the process industry and the propositions of the leading AI and BD-driven business models.

The results of this analysis revealed that the AI and BD contribution mainly deals with solutions dealing with the processes and products (more than 50% of the solutions analysed). The main value proposition AI and BD solutions provide is optimised process (23%) followed by process control improvement (12%). The results achieved and applications are clearly interrelated.

Different gaps were identified according to the business concerns identified by the sector and the AI and BD applications. The gap analysis revealed feasible opportunities for the transferability of AI and BD solutions between sectors. The main transfer opportunities according to common business concerns of the different sectors are related to a better understanding of value chain, high energy consumption, security, and human safety. The main transfer opportunities regarding the AI and BD applications identified by the consulted experts range from quality prediction, to achieving zero defects, process optimisation, energy saving and failure prediction.

AI-CUBE has identified 11 business trends with impacts in 4 different areas: environmental, operations/logistics, human and commercial/sales. These trends include sustainable, circular, symbiotic, human-centred, proactive predictive (proactive monitoring and maintenance), hyperconnected, quality assessment, AI-as-a-service, customer-driven, intelligent customisation and collaborative. From the previous business trends, seven business models were defined (and one mainstream, common to all the BMs) that can be used alone or by combining several of them.

	DESCRIPTION	BUSINESS MODEL	TREND
ENVIRONMENTAL IMPACT	Profitable and resilient activities that benefit society and the environment.	**SUSTAINABLE**	**HYPERCONNECTED** Agile, dynamic supply chains that flex to changes in demand through seamlessly integrated planning and execution.
	Preserving value in the form of energy, labour, and materials by designing for durability, reuse, remanufacturing, and recycling to keep products, components, and materials circulating in the economy.	**CIRCULAR**	
	A collaborative and hyperconnected approach to the physical exchange of materials, energy, and services between partnering firms and utility sharing of related infrastructures in dynamic SCs, creating value from waste across the network.	**COLLABORATIVE SYMBIOSIS**	
HUMAN IMPACT	AI serves humans by learning from human collaborations and is based on systems that are nurtured and constantly improved, facilitating human work by optimising their role in the factory, and enhancing and giving value to their knowledge. Focussed on the human experience, it prioritises the customer experience as well and uses customer needs to guide every facet of operations.	**HUMAN FIRST**	
OPERATION & LOGISTICS IMPACT	A proactive and predictive approach helps companies plan better, make smarter decisions, run smoother and improves productivity	**PROACTIVE & PREDICTIVE**	
	Increases efficiency and effectiveness of the production and management of the manufacturing and key processes in the organisation through the analysis and exploitation of data and process control.	**DATA USE / CONTROL FOR SC**	
COMMERCIAL IMPACT	Customers pay a fixed fee per unit of service consumed, while the ownership of the system remains with the technology provider (responsible for all operating costs). This strongly incentivises the service provider to think long-term when designing and selecting the technology.	**AI-AS-A-SERVICE**	

After the validation of the main trends and business models identified by AI-CUBE, we recommend companies from the process apply these trends and BMs to adapt

the current BMs to the AI and BD technologies to maximise their benefits. This will allow the process industry to boost the implementation of AI and BD solutions by providing specific gains in the short and long term.

T4.2 focussed on designing the AI-CUBE Business Model Game and developing workshops to collect practical use cases. In the game (simulation), each group (5 people minimum) selects a real-life use case from a particular SPIRE sector concerning an AI/ BD application associated with a different AI-CUBE Business Model matching the participants' experience.

AI-CUBE organised different in-person and online workshops to validate the game and provided the project with use cases for the business models identified. Through the game, the stakeholders brainstormed the challenges/barriers and the potential AI and BD technologies companies could use to overcome them.

T4.3 gathered all the results of T4.1 and previous work packages and translated them into ten guidelines tailored per sector. The AI-CUBE guidelines include the business models identified in the project and other resources to help remove barriers and provide new opportunities for AI and BD technologies in new processes and sectors according to the different macro areas of application by integrating the use of AI and BD technologies with current business models and organisational models.

Finally, **T4.4** provided AI-CUBE with a revision of the ethical, legal and social implications of AI and BD developments, considering the values encoded in algorithms, the need to evaluate outcomes, and issues of bias and transferability, data ownership, confidentiality and consent, and legal, moral and professional responsibility. The potential effects for clients and different actors in the supply chain (human operators), including confidentiality and process control systems and plants for seamless collaboration, have been explored through literature analysis and interviews with industrial experts.

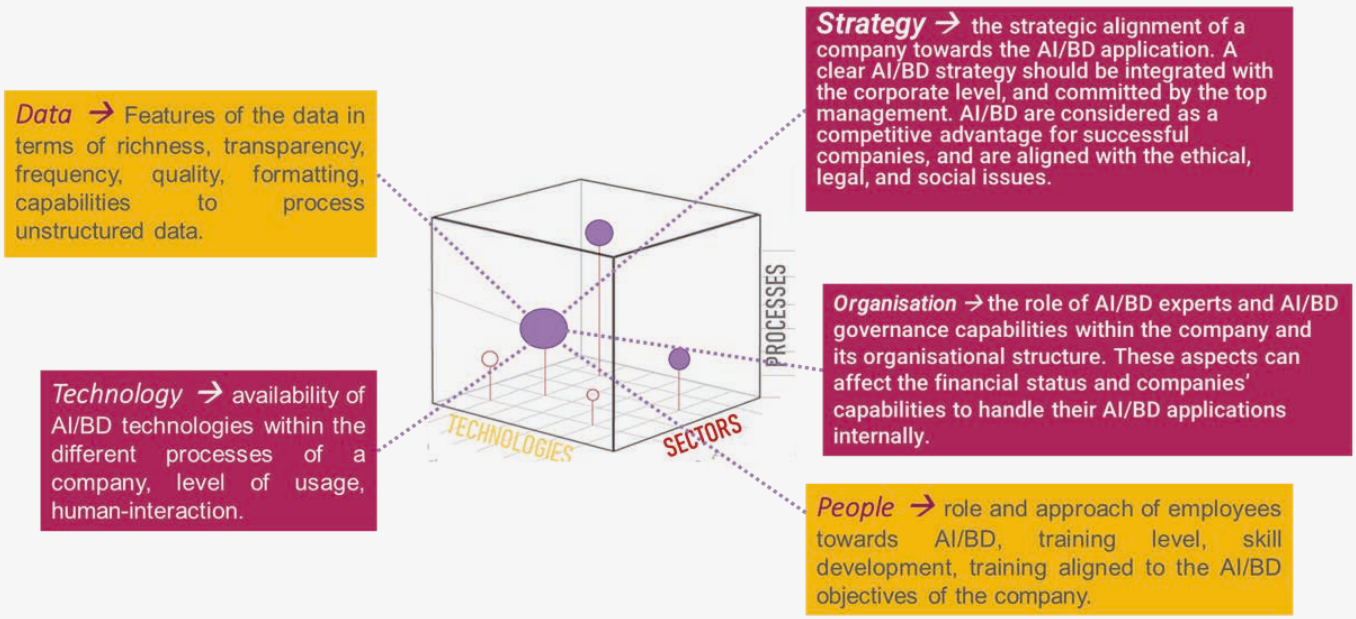
Maturity of AI and BD implementations in the Process industry from different perspectives THE MATURITY LEVEL ASSESSMENT MODEL

Maturity Level Assessment (MLA) Models have proved to be essential instruments to support the positioning of organisations in a specific comparative framework and help find better solutions for change. MLA Models have also become a well-established tool in digitalisation to support corporate management in complex and novel technology transformation processes, and to help understand the gaps in the digitalisation path.

AI-CUBE MLA models is conceived as a multi-stage model to capture patterns in the development of organisational capabilities along different dimensions. For each maturity level, the MLA model describes corresponding steps of development for relevant dimensions. These steps to full implementation of AI and BD have been logically connected and generalisable to identify the correct maturity level of an organisation.

THE 5 DIMENSIONS OF THE AI-CUBE MLA MODEL

The MLA model is organised along 5 dimensions. For each of them there are some sub-dimensions that companies can investigate to understand their level of maturity in implementing AI and BD technologies. Ethical and social dimension is considered in this model with questions related to people and the level of interaction between people and technologies.



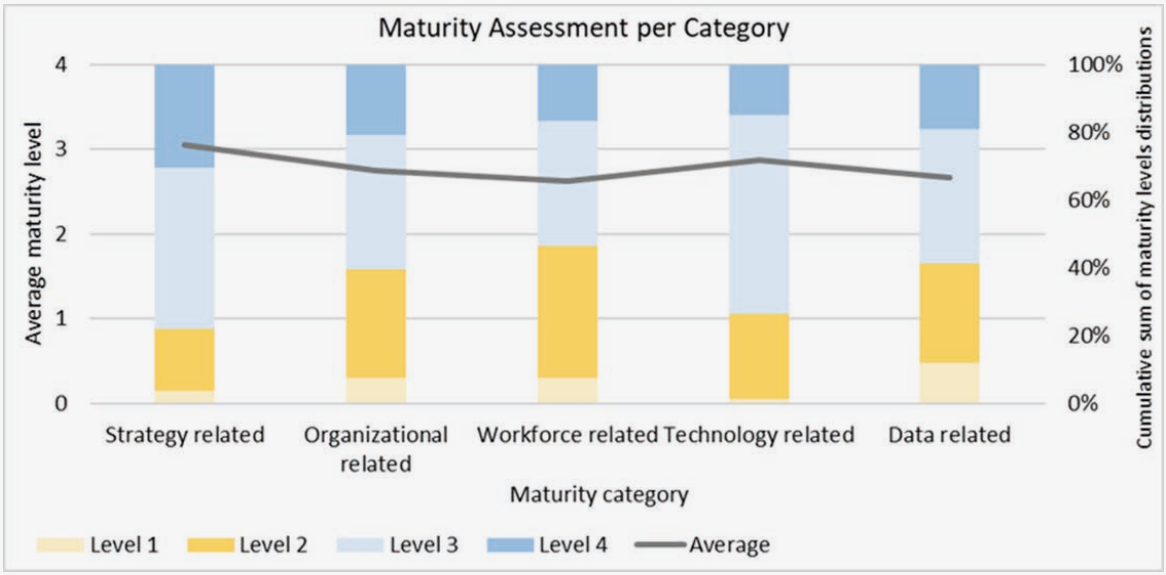
Find the online survey at:

User Survey: https://websites.fraunhofer.de/ai-cube/index.php/577833?lang=en

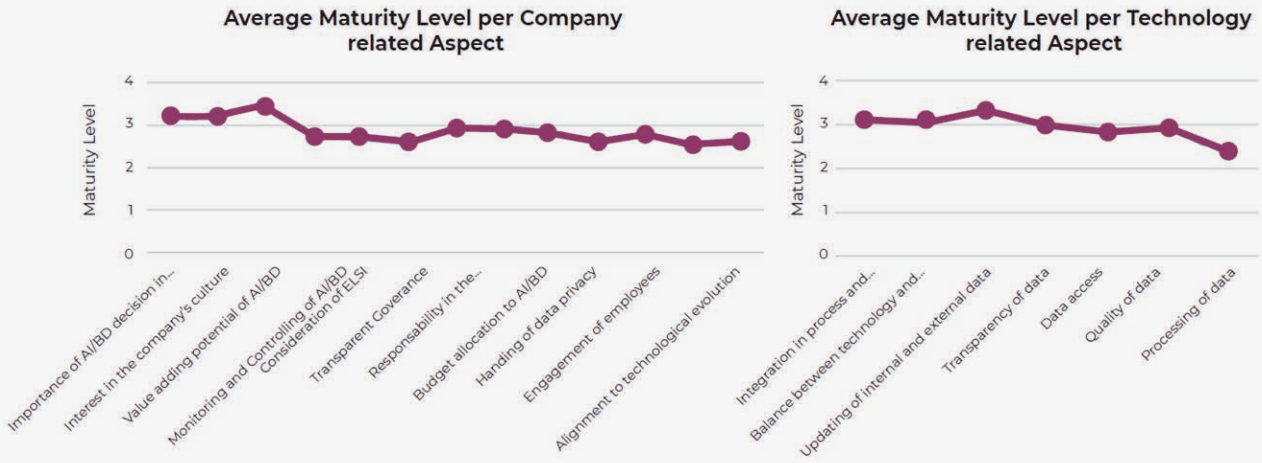
Provider Survey: https://websites.fraunhofer.de/ai-cube/index.php/759995?lang=en

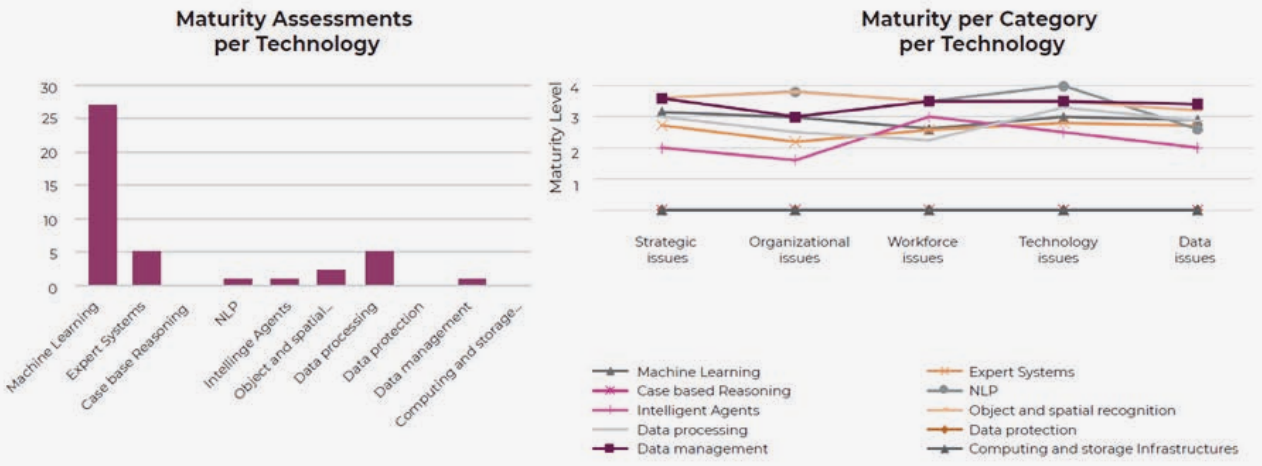
Main Findings

The MLA model was implemented and distributed through an online survey to companies in the process industry. Both users and providers of AI and BD technologies have been involved in the assessment to have a different perspective on the sector's maturity in implementing these technologies. In particular, the results collected with the preliminary set of contacts show that the implementation of AI and BD technologies in the process industry already has a high maturity. On average, the highest maturity is in strategic considerations, meaning that the sector perceives that implementing these technologies needs to be based on a solid commitment from the company's management.



Results per technology show a good balance between internal and external data while there is still low maturity in the capability to process data.





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https://www.pnoconsultants.com/it/

ZARAGOZA LOGISTICS CENTER

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FRAUNHOFER GESELLSCHAFT E.V.

http://www.fraunhofer.de/en.html

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