AI CUBE

# IMPACT ASSESSMENT OF AI&BD TECHNOLOGIES IN THE INDUSTRY

CSCMP edge 2021

SUPPLY CHAIN EDGE EUROPE
CONFERENCE & EXHIBITION
MILAN & VIRTUAL, JUNE, 10th-11th 2021

CSCMP

# AGENDA

- Introduction to the project and preliminary results
- Introduction to the workshop
  - Impact of AI: General & Process Industry
  - Real use case applying the methodology
- Group discussion
- Wrap up

# AI-CUBE OBJECTIVE

**8 AI and BD roadmaps**

indicating a route map and practical recommendations on AI and BD business cases, transferability of good practices from other industries, data, skills and RD&I requirements

- **Harnessing and optimising the potential of AI and BD in the European process industry**
- **Roadmap definition** as guidance to **researchers**, **managers** and **operators**
- **Specific recommendations** for all involved industrial sectors and organisations' functions and processes

# AI-CUBE Specific Objectives

1. Draw a 4-dimensional **AI and BD map (or a "CUBE")** with good practices available in the different organisational processes across 8 SPIRE process industries, assessing **current state-of-play and level of penetration of AI and BD** in different sectors;
2. Identify **good practices** to build on towards **future AI and BD business cases** and define the RD&I actions needed in a roadmap per sector;
3. Detect the **white spots of AI and BD solutions**, that can be covered by good practices from other process industries, and outline the roadmap towards adapting good practices for other sectors;
4. Define the **data requirements, skills and RD&I requirements** for future AI and BD business cases to emerge within the different process industry sectors.

# AI-CUBE IMPACT

| Expected impact | AI-CUBE impact |
|---|---|
| ***Better exploitation of AI potential for process industries sectors, and strategies for developing AI applications, including the generation of data*** | **Deep stakeholder involvement for shared understanding of AI and BD technology potential in the process industry** and detection of steps for their **improvement and effective application.**<br><br>Identification of necessary ecosystem capable of boosting data-driven technologies application, scaling and diffusion across industry sectors and value chains. |
| ***Identification of existing and future data requirements for the development of data driven technologies*** | **Identification of methods, tools and processes already available to acquire relevant data**; **processes** for data gathering to improve financial, operational, and environmental performance; **potential contribution of AI** to data collection and analysis and its involvement in the decision-making processes. |
| ***Seamless collaboration of human operators with process control systems and plants: acceptance, identification of skills gaps and ethical, legal & social implications (ELSI)*** | Interviews and workshops to identify existing and possible **fields of machine-human-interaction (HMI)**, **levels of acceptance**, **needs for skills development and technologies adaptation**.<br><br>Revision of ethical, legal and social implications of AI and BD developments, and required skills for a seamless collaboration of human operators and will analyse the current skill gaps in the industry to get ready for new implementation. |
| ***Implementation and further elaboration of the strategic research and innovation agenda announced in the EC Communication on AI*** | Combination of **diverse approach and perspectives**<br><br>Clarification of **wider socio-economic-cultural impact of data-driven technologies**, to draft a **comprehensive roadmap** fostering further application of the technologies and **guide strategic decision making** in Europe. |

# Consortium

AI CUBE

PNO

CiaoTech

ZLC

MIT GLOBAL SCALE NETWORK

IRIS

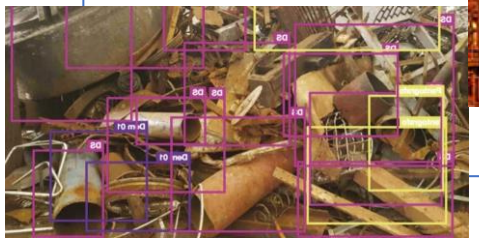
Fraunhofer IML

# The matching

Which are the needs?



Which is the impact?



# Artificial intelligence


- **Natural language processing - (NLP)** subfield of linguistics, computer science, and artificial intelligence concerned with the interactions between computers and human language. Data can be in the form of written text or human speech recognition.

Applications include machine control, interactive robots, and automatic synthesis and information retrieval of industrial information captured in a textual form.

- **Object and spatial recognition** – technology related to computer vision and image processing that deals with detecting and recognising instances of semantic objects of a certain class in digital images and videos.

Applications include industrial robots and autonomous vehicles; recognition of objects and components during "picking"; SLAM (Simultaneous localization And Mapping).

# Artificial intelligence

- **Machine learning** –algorithms to train/build data models which "learn from experience" represented in the data.
  - Some examples are supervised learning, unsupervised learning and reinforcement learning where a "teacher" is in the loop to give "reward" feedback for correct decisions.
  - Deep learning uses artificial neural network algorithms with many layers. Applications include: computer/machine vision, speech recognition, natural language processing, audio recognition, machine translation, bioinformatics, image analysis, material inspection, among others.
- **Expert systems** –to emulate the decision-making or diagnostic ability of human experts. Designed to solve complex problems by reasoning through bodies of knowledge.

Applications include as computer vision, process simulation and predictive maintenance.

Applications include complex process control, intelligent planning, setting calibration parameters, predictive maintenance and diagnosis.

# Artificial intelligence

- **Case-based reasoning –**solving problems based on the solution of similar past problems; it is an example of analogy solution making which humans commonly use every-day to solve problems.
  - Four key steps: “Retrieve” (obtain previous cases), “Reuse” (adapt previous case to new situation), “Revise” (test and further adapt as necessary), “Retain” if the new adapted case has resulted effective, store it for future use.
- **Intelligent agents** –refer to a set of processes which interact between themselves and with the environment in an “intelligent” manner to achieve the fixed goal.
  - Multi-agent systems can be used for the creation of Cyber-physical systems (CPS) as systems where a mechanism is controlled or monitored by computer-based algorithms → network of elements that interact with each other via physical inputs and outputs, related to the fields of robotics and sensor networks.

# Big data

- **Data visualization -** interdisciplinary field of study whose object is the representation of data in graphical format. It is particularly efficient when the amount of data to be represented is large.
  - Key applications include “dashboard” displays for complex process real-time control systems, and management decision support systems.
- **Data protection** – relationship between the collection and dissemination of data, technology, the public expectation of privacy, and the legal and political issues surrounding them. It is also known as data privacy or information privacy.
  - In industrial terms it can be related to cyber-security and the protection of installations from cyber-attacks, as well as industrial secrets, patents and confidentiality.

# Big data

- **Data processing** – collection and manipulation of items of data to produce meaningful information. It may involve various processes, including: validation, sorting, summarization, aggregation, analysis/interpretation, reporting and classification.
- **Data management** - comprises all disciplines related to managing data as a valuable resource.
  - In a digital context, it offers tools to facilitate the management of data and improve performance, consisting of an integrated, modular environment to manage enterprise application data, and optimize data-driven applications over its lifetime.
  - It includes the following objectives: produce enterprise-ready applications faster; improve data access, speed iterative testing; automate and simplify operations; support business growth.
- **Computing and storage infrastructure** - provides the hardware and services that other systems and services are built on.
  - Some of the key ones are: file and disk storage service, file backup, long-term archive and ftp services; networks; authentication, authorization, virtual hosting, and cloud computing services.

# Use of AI and BD

| | Data understanding and characterization | Natural language processing | Object and spatial recognition | Machine learning | Intelligent planning | Expert systems | Case based reasoning | Intelligent agents | Cyber-physical systems | Data visualization | data processing | data protection | Data manage-ment | Computing and storage infrastructure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Model predictive) process control and optimization | 2 | 1 | 10 | 25 | 7 | 11 | 5 | 1 | 8 | 4 | 12 | | 6 | 3 |
| Market trends and open innovation | 4 | 2 | | 5 | | | | 1 | | | | | 1 | 1 |
| Predictive maintenance | | 2 | 2 | 5 | | 2 | 2 | 2 | 5 | | | | 1 | 1 |
| Product design/custom | | 3 | 1 | 10 | | 4 | 2 | | 4 | 2 | 2 | | 3 | |
| Research and innovation management, planning and design | 5 | | | 8 | 1 | | | 1 | | 1 | 2 | 1 | 7 | 2 |
| Supply chain management (re) configuring and scheduling | | 4 | | 6 | 2 | 2 | 1 | 5 | 3 | 1 | | 1 | 2 | 1 |

| HEAT MAP | |
|---|---|
| >9 | high |
| 4-9 | medium |
| 0-3 | low |

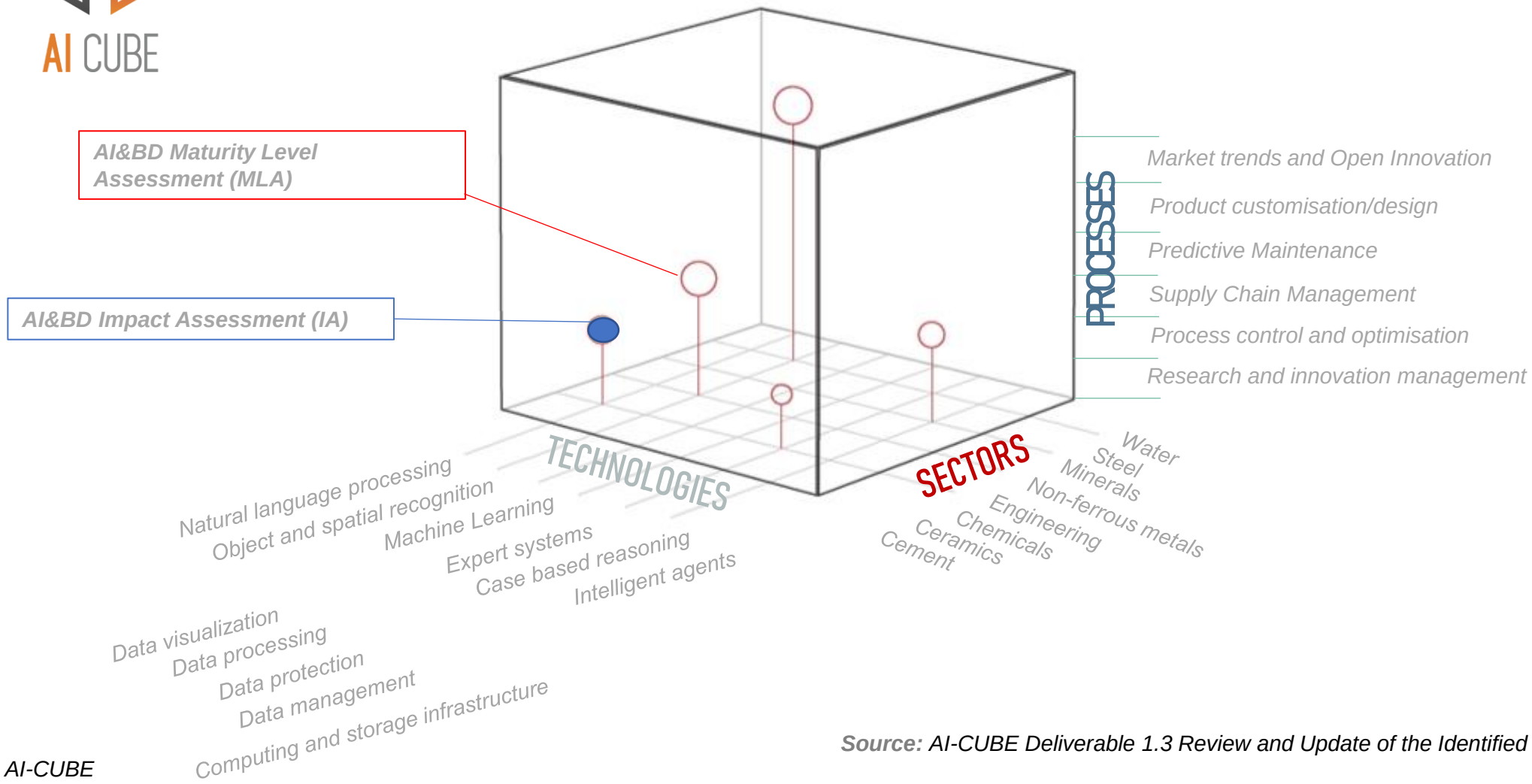
“Heat map” processes vs technologies

| | Data understanding and characterization | Natural language processing | Object and spatial recognition | Machine learning | Intelligent planning | Expert systems | Case based reasoning | Intelligent agents | Cyber-physical systems | Data visualization | Data processing | Data protection | Data manage-ment | Computing and storage infrastructure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cement | | | | 4 | | 3 | 1 | | 1 | 2 | 2 | | 1 | |
| Ceramics | | | 2 | 4 | 4 | 2 | 1 | 1 | 2 | 1 | 4 | | 2 | |
| Chemicals | 8 | | 1 | 10 | | | 1 | | 1 | | 2 | | 3 | 3 |
| Engineering | 1 | 8 | | 5 | 1 | 4 | 4 | 4 | 8 | 1 | | 1 | 5 | 3 |
| Minerals | 2 | 1 | 4 | 14 | 4 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 2 |
| Non ferrous metals | | | | 7 | | 2 | 1 | | 1 | 1 | 3 | | 1 | |
| Steel | | 2 | 5 | 8 | | 7 | 1 | 2 | 5 | | 2 | | 2 | |
| Water | | 1 | 1 | 7 | 1 | | | 1 | 1 | 2 | 2 | | 3 | |

| HEAT MAP | |
|---|---|
| >9 | high |
| 4-9 | medium |
| 0-3 | low |

“Heat map” sectors vs technologies

# AI-CUBE: General Approach




***Source:*** *AI-CUBE Deliverable 1.3 Review and Update of the Identified Macro Applications Areas Plan*

# Impact of AI: General

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AIRBUS & AUTODESK

Reinforcement learning to design/make sturdy yet light airline partitions. **45% reduction in weight.**

BRS BIG RIVER STEEL a U. S. Steel company & noodle.ai

ML to estimate: prices of scrap steel and finished steel, projected demand, wear & tear on their factory (captured by 50,000 sensors). **Increased profitability.**

GAP & KINDRED

Reinforcement/deep learning to transition robots from being human-operated to working autonomously. **Faster assembly of e-commerce orders with robots.**

| SUMMARY OF VALUE DRIVERS | | | | |
|---|---|---|---|---|
| **Design** | **Source/Make** | **Deliver/Store** | **Sell** | **Use** |
| Optimize product design basd on predicted customer behavior | Increase efficiency | Reduce delivery times | Analyze store foot traffic | Increase efficiency |
| Optimize product design based on desired criteria | Increase machine uptime | Improve fuel efficiency | Improve conversion | Automate customer service |
| Iterate product design faster | Minimize input price risk | Increase warehouse efficiency | Improve conversion | Anticipate maintenance |
| Personalize product | Reduce delivery times | Reduce inventory | Personalize marketing | |
| | Optimize input purchase timing | Avoid weather-related delays | | |

Process Efficiency | Process Enhancement | Product or Service Innovation

OhmConnect

ML to optimize customer segmentation for campaigns based on household-level energy usage data, aggregated demographics data and weather forecasts. **3x Increased efficacy (higher user participation) in energy saving campaigns.**

STARBUCKS COFFEE

AI to customize the app based on customer's order history, along with current weather, date, and time to optimize food/beverage offers. **3x increase in response rate with personalized offers.**

***Source:*** *"Value Chain Innovation: The Promise of AI", by H. Lee, H. Mendelson, L. Blake, and S. Rammohan, Stanford GSB, 2018*

# Impact of AI: SPIRE Sectors (literature review)

| Sector | Process | Issues | Potential impacts |
|---|---|---|---|
| **Water** | (Model predictive) process control and optimization<br>Predictive maintenance<br>Research and innovation management, planning and design | Waste water processing, clean water processing. Complex processing chain, large processing volumes, yield. | Cost reduction, improved efficiency, energy saving, increased sustainability, optimized performance, data management |
| **Steel** | (Model predictive) process control and optimization<br>Supply Chain Management | Furnace, smelting. High energy consumption, risk to humans, quality control, logistics, Value Chain. | Improved performance, product optimized, successful process redesign, product quality prediction, informed decisions and workforce time saving, productivity/yield increased, process optimized |
| **Minerals** | (Model predictive) process control and optimization<br>Predictive maintenance | Milling of raw material, mining/extraction. High energy consumption, security and human safety, scheduling/planning, security, automation, remote monitoring. | Trends and market prediction, process optimized, quality control, fault detection and diagnosis, informed decisions, data processing, process improvement, process control improved, workforce safety improved, data protection |
| **Non-ferrous metals** | (Model predictive) process control and optimization<br>Predictive maintenance | Furnace, smelting. High energy consumption, risk to humans, scrap quality control, logistics. | Improved product characterization, informed decision making, optimized production process, process and consumption understanding, improved fault forecasting, |
| **Engineering** | (Model predictive) process control and optimization<br>Predictive maintenance<br>Supply Chain Management | Fault detection, quality assurance. Predictive maintenance, data quality, sensor data capture. | More efficient production, higher quality, improved customers needs identification, increased knowledge |
| **Chemicals** | Supply chain management (re)configuring and scheduling<br>(Model predictive) process control and optimization<br>Research and innovation management, planning and design<br>Supply Chain Management | Conversion of materials. Waste avoidance, process complexity, reliability, production planning, continuous sensor-based monitoring<br>process control logistics, goods shipments tracking. | Energy saving, improved process understanding and optimization, increased sustainability, improved quality control, data management achieved |
| **Ceramics** | Product customization/design<br>Supply chain management (re)configuring and scheduling<br>(Model predictive) process control and optimization<br>Research and innovation management, planning and design | Raw material processing, firing, finishing. High energy consumption, reduce defects (cracking/foaming) | Improved defects detection and quality control, product characterization, process optimization, optimized products, better production management |
| **Cement** | Predictive maintenance<br>(Model predictive) process control and optimization<br>Product design<br>Research and innovation management, planning and design<br>Supply chain management | Kiln, firing, material processing. High energy consumption, predictive maintenance, predict process behavior, supply chain, remote operation. | Product characterization, process improvement, higher efficiency, increased sustainability, better process control |

# Real use case

**Process-driven (EDC production) issues:**
- High levels of toxic/undesired side product (**quality**)
- Product loss during separation process (**yield**)

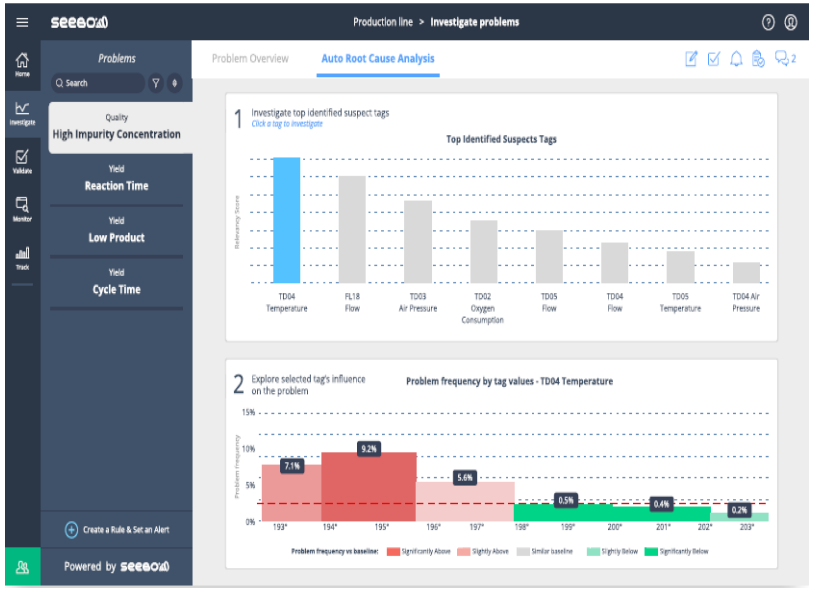
**DATA:**
- ❑ Information Tech.
- ❑ Operational Tech.
- ❑ Insights From Process Engineers

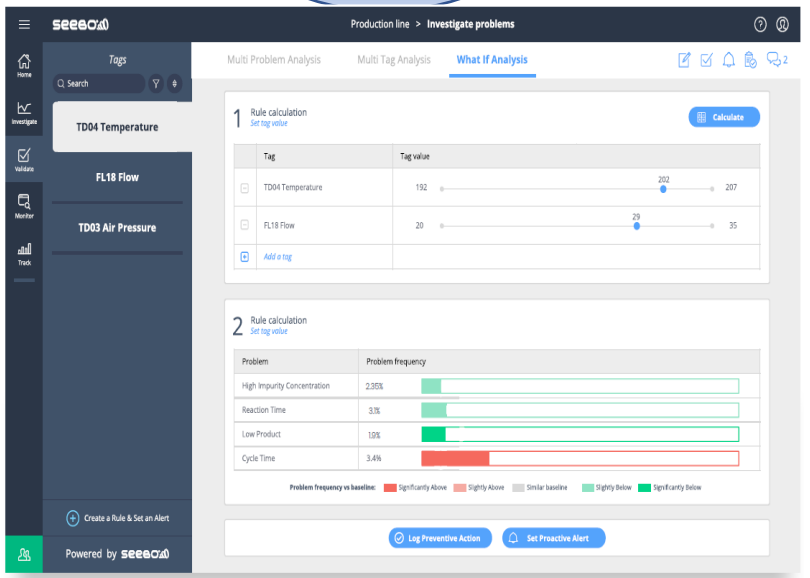
**IDENTIFY ROOT CAUSES:**
- ❑ 5 primary causes
- ❑ 2 major factors: different temperature around installation columns & flow rate to the distillation column

**SCENARIO ANALYSIS:**
- ❑ Optimal temperatures
- ❑ Optimal flow rates

Real-time supervised machine learning

Predictive Simulation




## AI-CUBE PROCESSES

**Market trends and Open Innovation** (*Sales, CRM, Consumer Behaviour & Market Scenario Analysis, Demand Mgmt. & Forecasting*)

**Product/Service Customization/Design and NPI**

**Predictive Maintenance**

**Supply chain management** (*Sourcing/Procurement, Production, Replenishment, Storage, Distribution, Reverse Log., Network Design, SRM, Contract Mgmt., Resource Allocation*)

**Process control and optimisation** (*Process/Equipment Monitoring, Quality Control, Process Redesign*)

**Research and innovation management** (*Scenario Based Opt. & Sim., HR mgmt., Risk Mgmt., Collaborative Innovation Platform, Process Redesign*)



**Source:** *CASE STUDY Chemical Manufacturing. Seebo*
*Opportunities of Artificial Intelligence. European Parliament 2020*

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## Other potential issues??

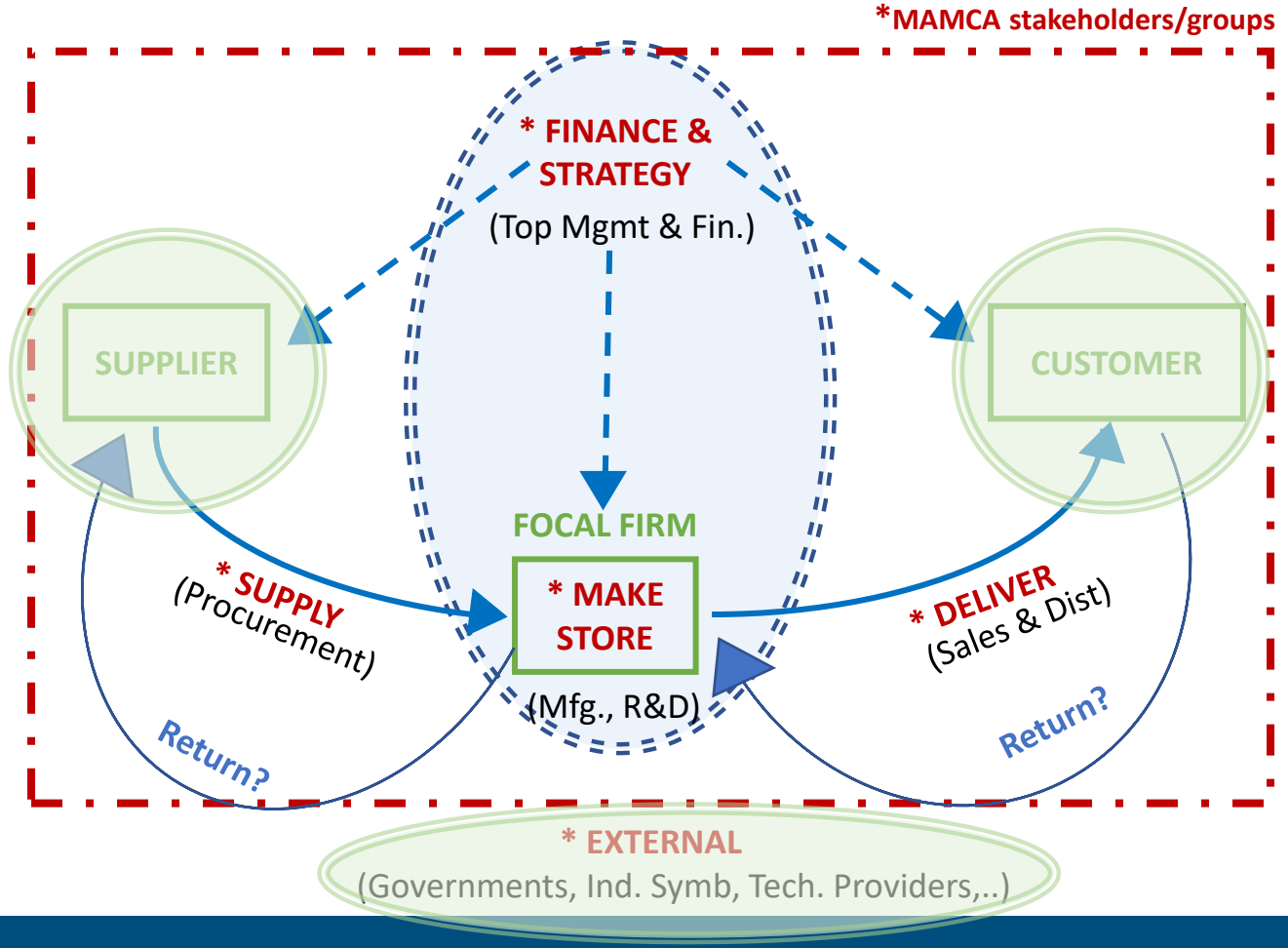
98% of demand for the production of one product (Vinyl Chloride Monomer), with significant growth
Concentrated Supply Base (USA, Northeast Asia, Europe)
Sustainability
…

### SALES & FINANCE

*Increase in the company profit*

### PLANT

- *Digitally supported dedicated teams of operators, pooled for larger plant clusters, to handle problems and unexpected events*
- *Better yield with increased first-time-right production*
- *Significant efficiency improvements in production processes*
- *Reduced plant downtime and increased overall plant lifetime*




### RESEARCH & INNOVATION

*Predictive analytics to help design experiments and interpret results*

### HUMAN & ORGANIZATIONAL

- *Better availability of information*
- *Provides the scope to gain new/better insights through improved use of existing data*
- *Enable the human workforce to be more effective, efficient & creative*

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NOW WE NEED YOUR INPUT AS TO WHAT THE IMPACT OF AI & BD WOULD BE FOR YOUR BUSINESS CONSIDERING THESE ENTITIES AND PROCESSES…

# Human and organisational impact

HO9 – **Trust in AI&BD Tech. Addressed** →Trust is quite an issue when deploying AI based solutions, hence a wide range of human and social sciences issues will need to be addressed

HO1 - **Better Availability of Information** → operators and plant controllers can make improved decisions

HO8 - **Transfer and formalise operators' knowledge and best practices**

HO2 – **New & Better Insights** → Provides the scope to gain new and better insights through improved use of existing data which otherwise would overwhelm humans

POTENTIAL IMPACT

HO7 – **Better Working Conditions** → Improve the operators' working conditions by simplification of human-machine interface with complex processes

HO3 - **Accelerate human/operators learning**

HO6 – **Improved Safety** → Reduce human involvement in physical tasks in dangerous working environments

HO5 - **Automate repetitive, transactional and judgment-related tasks**

HO4 – **Enabling workforce to become more effective, efficient, and creative**

# Poll - Human and organisational impact

| Choose the most relevant impact of AI & BD technologies | # of votes |
|---|---|
| HO1 - Better availability of information | |
| HO2 - New and better insights | |
| HO3 - Accelerate human learning | |
| HO4 - More effective and efficient workforce | |
| HO5 - Automate repetitive, transactional and judgment-related tasks | |
| HO6 – Increase human safety | |
| HO7 - Improve the operators' working conditions | |
| HO8 - Transfer & formalise operators' knowledge and best practices | |
| HO9 - Trust in AI&BD technologies addressed | |

# Research & Innovation

R1 – **Help Design/Perform Experiments** → Predictive analytics based on internal and external data can be used to help design experiments and interpret results

R6 – **Improved Marketing and Product Design Cycles** →AI can impact marketing and product design cycles, or even dramatically change the value cycle

POTENTIAL IMPACT

R2 – **Faster Innovation Cycles** → Achieve superior product quality by faster and better innovation cycles using data-driven R&D systems, data-driven R&D through in-silico experimentation and advanced lab automation

R5 - **More Flexible and Customer-driven Innovation** → production of customisable goods, ultimately with the help of other technologies, leading to a dramatic change in the value-chain

R3 – **Improved Evaluation of Existing Products** → Better analysis of the performance of existing products for the improvement of future products based on lifecycle data

R4 – **Material Design & New Customized Products** → Data analytics in material design and simulation in order to accelerate new and customised product development

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# Poll - Research & Innovation

| Choose the most relevant impact of AI & BD technologies | # of votes |
|---|---|
| R1 – Help to design for experiments | |
| R2 - Faster innovation cycles | |
| R3 - Analysis of previous products | |
| R4 - Material design and new customized products | |
| R5 - Flexible and customer-driven innovation | |
| R6 - Impact on marketing and product design cycle | |

# Plant

P10 – **Improved Coordination of SC** → Supporting the optimisation of the whole production chain, the holistic coordination of new operational goals and the integrated management of production

P1 – **Improvement in Efficiency** → Significant efficiency improvements, even in production processes that have been already optimised for decades in process industries

P9 – **Longer Overall Plant Lifetime** → AI augments supervision activities such as maintenance routines, helping to reduce plant downtime, superfluous routine maintenance activities and component spare part replacements, and to increase overall plant lifetime

P2 – **Less Energy Consumption** → Reduced energy requirements through ML based optimisation, improved spot vs. contracting mix for energy sourcing, intelligent coupling of production plants/sites with renewable energy grids

POTENTIAL IMPACT

P8 – **Eliminate Routine-based Manual Works** → Tedious, routine-based manual work becomes obsolete, safety and quality reach unprecedented high levels

P3 – **Better handle unexpected events** →Dedicated digitally supported and dedicated teams of operators, pooled for larger plant clusters, to handle problems and unexpected events

P7 – **First-time-right production and increased yield**

P6 – **Solve Complex Optimization Tasks** → Intelligent Digital Twins combined with Software Agents to communicate with each other to solve several types of complex optimisation tasks --> *self-organisation of industrial production*

P5 - **Production data is fully and seamlessly available for R&D and customer service activities**

P4 – **Real-time Data for Digital Twins** → Data scientists, process engineers and production managers supervise autonomous plants and use real-time digital-twin simulation to optimise operations constantly towards higher energy, resource efficiency and better product quality

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# Poll - Plant

| Choose the most relevant impact of AI & BD technologies | # of votes |
|---|---|
| P1- Improvement in efficiency | |
| P2 - Reduce energy consumption | |
| P3 - Handle unexpected events | |
| P4 - Real-time data for digital twins | |
| P5 - Production data support R&D and customer service | |
| P6 - Solve complex optimization tasks | |
| P7 - First-time right production | |
| P8 - Eliminate routine-based manual works | |
| P9 - Increase in overall plant lifetime | |
| P10 - Support the coordination of the SC | |

# Value & Finance

F3 – **Higher Profits** → Increase in the company profit (margin & sales) due to the implementation of AI&BD technologies

V1 - **Create new services and flexible and customer-tailored offerings**

F2 – **Better Margins** → Increase in the sales of the company due to better customer knowledge, product design, new customized products, market understanding

V2 – **Improved Understanding of Customers Needs** → Deeper understanding of customers' experience and behaviour and better identify new applications/markets for existing and new products

POTENTIAL IMPACT

F1 - **Reduction of the manufacturing cost of the products**

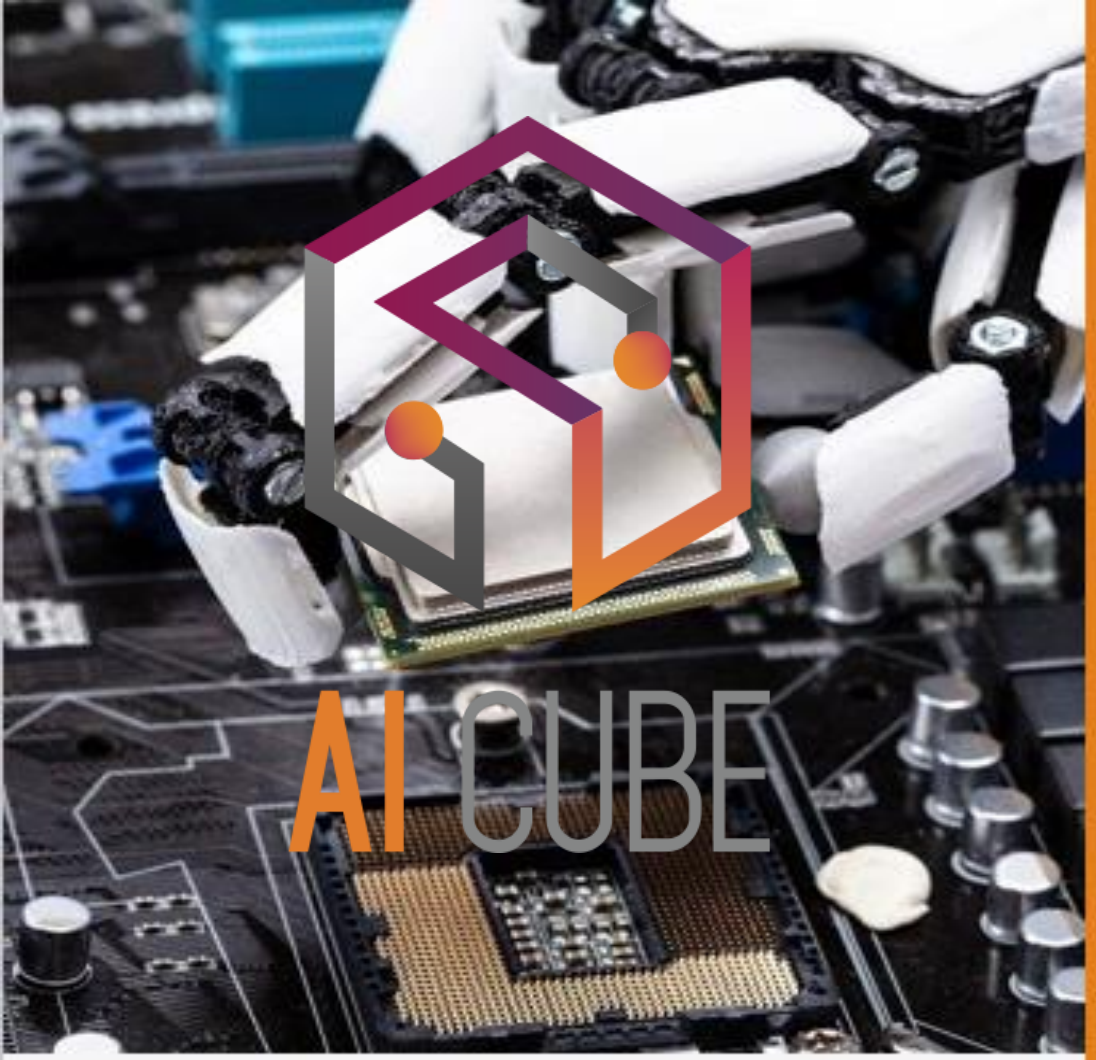
V3 – **Proactive Sales** → Conduct highly targeted, proactive sales with AI-based customer-specific forecasting and demand sensing, which could make it possible to ship goods even before the customer places orders so customers will never run out of the product

V5 - **Realisation of Industrial Symbiosis** → by tight coupling of production units (streams of materials and/or energy) through simulation of operating conditions of all involved plants of all participating companies, also across SPIRE sectors

V4 - **Better demand forecasting** will reduce storage requirements and look-up value

# Poll - Value & Finance

| Choose the most relevant impact of AI & BD technologies | # of votes |
|---|---|
| V1 - Create new services & customer-tailored offerings | |
| V2 - Deeper understanding of customers | |
| V3 - Proactive sales | |
| V4 - Better demand forecasting | |
| V5 - Realisation of industrial symbiosis | |
| F1 - Reduction of the manufacturing cost | |
| F2 – Higher profit margins | |
| F3 - Increase in the company profits | |

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# Thank you!