EUCloudEdgeIoT.eu

Market Pathways for Cloud Edge IoT in Manufacturing

White paper

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Traditionally, the level of digitalisation and automation in manufacturing is and has been high when compared to other sectors. The main driver for the adoption of both digital and, in particular, CEI solutions is the efficiency enhancement of production processes, which includes dealing with rising energy and resource prices. For a long time, the motivation for decision-makers to employ digital solutions was the efficiency improvement within individual companies neglecting the linkage to suppliers, partners and customers. About ten years ago, however, the Industry 4.0 paradigm shifted attention to the potential of cross-enterprise collaboration. Promising use cases involve e.g. warehouse management, tracing causes of quality issues along the value chain or predictive maintenance to reduce downtime.

Today, dealing with cross-company aspects is no longer a sheer question to make production process more cost-efficient. Companies might be legally obliged to provide detailed information on the carbon footprint of their products and to issue European Digital Product Passes[1] in the next years. The employment of CEI technologies can have significant advantages in tackling the mentioned challenges, since they cannot be solved without cross-company collaboration or targeted data sharing. Providing sufficient data sovereignty is critical to enabling data exchange and, in the future, open ecosystems, which is why CEI technologies are a key enabler to address many challenges in manufacturing.

We will discuss the technological challenges and available solutions to increase the efficiency of production processes as well as certain market paths for European companies. We will point out the critical dependencies of non-European market players and highlight the market paths taken by innovative European CEI solution providers in manufacturing.

1 https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_en

2 CEI solutions as an enabler to realize the industry 4.0 paradigm

Applying CEI solutions in manufacturing is a highly promising path to unlock the full potential of data-driven analysis, decision making and automation. In an Industry 4.0 logic, this includes vertical integration from the asset to the business layer within companies, and horizontal integration across different facilities and along the (cross-enterprise) value chain.

In manufacturing, the technology stack for relevant solutions deployable to the CEI-continuum today is already quite rich and mature compared to other domains. There is a huge amount of product and service offerings related IoT devices and platforms as well as orchestration and analytics solutions.

Yet, to address the user and technical requirements and to pave the way for open European data ecosystmes, the following aspects to interconnect systems are known to be highly relevant:

- **Data sovereignity:** Maximum control for involved stakeholders (e.g. machine and component manufacturers, machine operators) over their data
- **Interoperability:** Standardized interfaces to connect hard- and software components and modules from different providers.
- **Openness:** Limiting vendor lock-in effects and facilitating the uptake of innovative solutions for manufacturing companies.

As the latter two aspects of interoperability and openness are considered crucial by many stakeholders (e.g. UniversalAutomation.org, IDTA, OPC UA Foundation), there have been various important activities in the manufacturing domain adressing those. Future CEI solutions can and should build on these results and play a key role in addressing the unresolved data sovereignty issues that are essential for the adoption of the technology in this area.

2.1 Specific Challenges for CEI in manufacturing

Due to the critical role that CEI technologies can play in the manufacturing sector, a significant number of R&D and research projects have been or are being initiated by private companies or by European or national funding programmes. At the same time, industrial platforms already exist that allow for orchestration of industrial IoT devices and management from assigned control centres.

The challenge in manufacturing is therefore not a lack of solutions. Rather, the challenge in manufacturing is to harmonise the many existing initiatives and technical and technological approaches. The establishment of standards in Europe is the only viable solution to ensure interoperability between hardware and software components from different machine or component manufacturers or service providers in the EU. The use of open standards and interfaces brings many benefits to innovative companies that do not have a strong market position. It stimulates competition for innovative products and also helps companies to comply with EU Data Act.

The second major challenge in establishing CEI solutions in manufacturing is to increase the acceptance of a particularly important target group. SMEs, in particular, are still reluctant to integrate such solutions due to uncertainties about the return on investment, possible lock-in effects or simply the inability to assess the potential benefits of such solutions.

2.2 Approach and analysis methodology

In the following, we would like to illustrate which innovative solutions and Cloud-Edge-IoT technologies are already available on the market and how they can enable the realization of the industry 4.0 paradigm. To understand the current state of this transformation process, we analyzed the CEI market dynamics in manufacturing in particular:

- Who are the big tech players in the CEI market and which services do they offer?
- How the big tech CEI players cooperate with big players from the Manufacturing sector?
- Which players in the Manufacturing sector provide new innovative solutions? And how these solutions contribute to the transformation in the Manufacturing Sector?
- Where are the major dependencies from the big tech players and the resulting risks? What are market pathways and opportunities for CEI companies in the Manufacturing sector?
- Are CEI and Manufacturing markets ready for data sharing?

To explore the potential for innovation in these areas, we mapped the CEI players to the building blocks and conducted workshops, supplemented by in-depth interviews with industry experts. We asked questions about how their products, platforms and services would contribute to innovation in the areas illustrated. We also discussed the level of demand-side adoption of data sharing, open source software and hardware architectures in manufacturing.

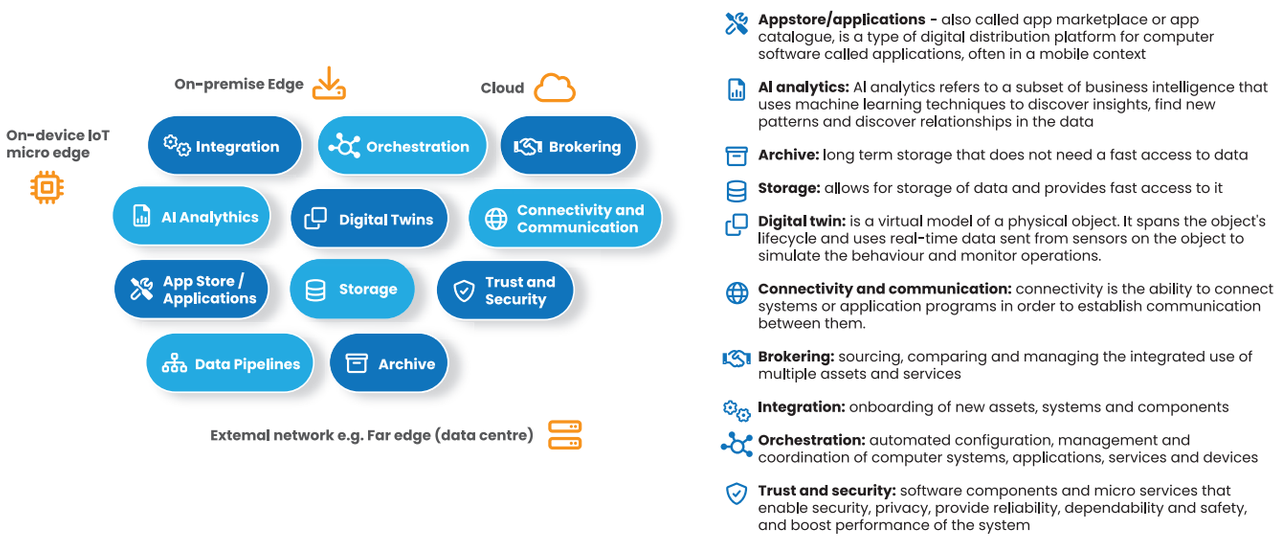

Figure 1: Cloud-Edge-IoT Building Blocks - Source: UnlockCEI

2.3 CEI infrastructure providers and the market dynamics in Manufacturing

Hyperscalers such as AWS[2], Microsoft[3], IBM[4], etc. are increasingly expanding their cloud infrastructure and service portfolios to include manufacturing-related service offerings. In terms of the CEI continuum, this is more about cloud and edge layers and less about IoT-related products.

At the same time, there are companies with a long history in the field that combine CEI building blocks to address manufacturing needs. In particular, the 'big' players (e.g. Siemens, Bosch, Schneider Electric) offer CEI solutions and have identified opportunities to connect to the services

2 https://aws.amazon.com/iot-core/?nc1=h_ls
3 https://learn.microsoft.com/en-us/azure/iot-edge/about-iot-edge?view=iotedge-1.4
4 https://www.ibm.com/products/maximo/environmental-health-safety

of SMEs and start-ups and have established corresponding application programming interfaces. Overall, the manufacturing landscape benefits from a diverse ecosystem of CEI companies actively contributing to innovation and connectivity.

2.3.1 Innovative solution: Contact Software

With its roots in product lifecycle management, Contact Software is a German company with a clear focus on developing new innovative solutions and using open standards and interfaces within its existing IoT and platform solutions applicable to the CEI continuum.

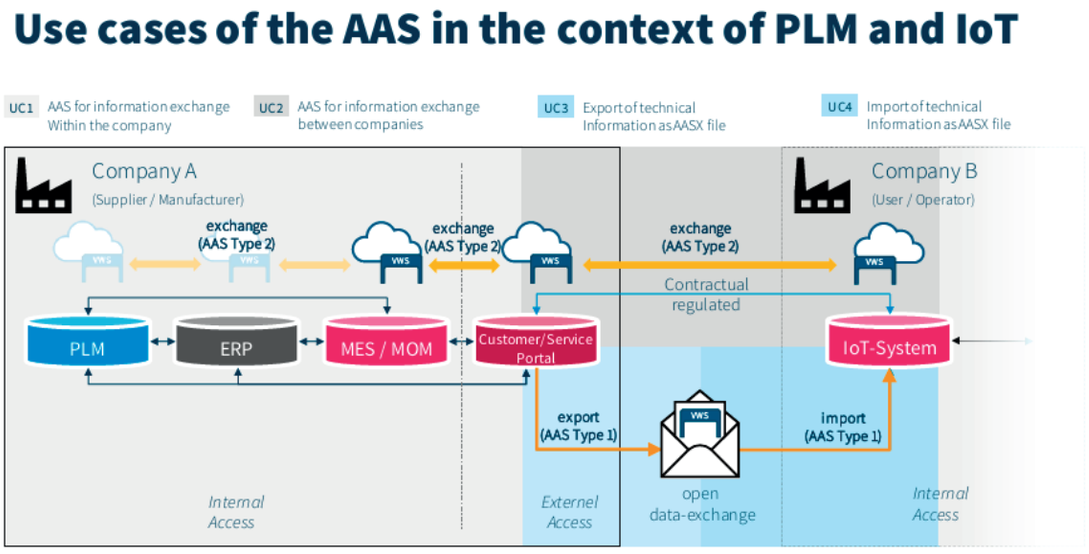

Figure 2: Use cases of the asset administration shell (AAS) in the context of product-lifecycle management (PLM) and IoT

All solutions rely on the same basic technology platform and follow similar concepts to provide openness and easy applicability to companies in the manufacturing domain. Allowing for an open interaction between software products and factory planning tools as well as data-sharing between platforms are crucial features in the product and market strategy of Contact Software. Therefore, the employment of the digital twin, in the form of the asset administrative shell (AAS) as proposed by the International Digital Twin Association, plays a pivotal role in the ecosystem of Contact Software comprising of 2,000 company customers from different countries. Within the Contact Software ecosystem, the AAS is supposed to support the connection of all different kinds of business software and to cover the whole product lifecycle. AAS-support for customers is also already provided in the commercial product of Contact Software since the end of 2023. This makes it possible for every customer to start to develop and integrate AAS-based models with further extensions planned in 2024.

According to Contact Software, embedding digital twins in real-world application environments, such as smart factories, smart products and service ecosystems, is critical to the implementation of many innovative solutions. The company sees digital twins not only as an enabler for more efficient management of production orders, workforce management and production planning tools, but also as an enabler for closed-loop engineering. Closed-loop engineering is one example of a promising interaction between business software components and smart factories or smart products in this context. Contact Software aims to feed relevant information from operational data e.g. from IoT assets back to the planning phase of new products or the improvement of existing products. Taking this into account, Contact Software employs open standards not only to provide the necessary interoperability, but also to develop relevant services for their customers.

At the same time, Contact software offers a flexible platform where computation processes can be assigned to different layers in the CEI continuum. In general, the decision which type of components

of analytics tasks are better executed on an edge device or in a cloud environment is a use-case-specific question. However, in many cases the decision can be based on latency requirements and the relevance of the results and derived information. If detailed information is less relevant for the overall process management and when low latency is needed, analysis parts are better executed in the edge environment. When abstraction and complexity and the analysis is very important and low latency is less relevant, then execution to the cloud environment is the favorable strategy. While this strategy can serve as a basis for informed decisions on and an automation of process orchestration, the user is always in control to decide to which layers processes should be assigned to within the Contact software platform. Since the platform also comes with an intuitive control center and dashboard the users is flexible to configure CEI systems according to the individual requirements and preferences. Contact Software provides a responsive web user interface that's capable of working on mobile phones or tablets as well as many other resource-constrained devices.. This makes it easy for companies to adjust the solutions to their problems by themselves.

Additionally, the Contact Software platform is modular and supports common business application integration, e.g. connectors to SAP software. Open software interfaces, e.g. to Python, and the possibility to link respective libraries is supported as well as common protocols, e.g. OPC-UA, or messaging, e.g. MQTT. The capability to connect REST API allow for an integration of external applications to the Contact software platform and software.

As a company, Contact Software has a dedicated research unit ("Contact Research") involved in CEI-related research projects funded by German and European funding bodies. At the same time, Contact Software serves as an edge device supplier and develops joint solution with companies. Contact Software is also a member of different open initiatives supporting open source technology actively. Moreover, Contact Software is a member of the International Digital Twin Association (IDTA), where they support the development of the standardized industrial digital twin.

2.3.2 Innovative solution and project "KICKS4EDGE": Siemens

Siemens holds a strong position in the manufacturing domain and offers a huge portfolio of hard- and software products. Siemens must be considered as one of the "big players" and market leaders in the areas e.g. of product-lifecycle management (PLM) tools, industrial automation and control solutions, but also of the emerging field of industrial edge software and platforms. Siemens focuses on building digital twins around products, production, and in-service processes, which sets it apart from other vendors to a certain extent. Siemens is actively investing in the development of CEI solutions and continues to innovate in this space. The focus on digital twins and commitment to edge computing solutions contribute to its strong market position.

As an industry leader, Siemens is involved in numerous technology-driven research projects and in the most important initiatives concerning the interoperability of systems. In the major European initiative IPCEI-CIS[5] (being funded with approx. 3.5 billion EUR) over 100 companies and research institutes from 12 EU member states join forces to build a common cloud and edge infrastructure. Respectively, IPCEI-CIS aims to support the development of the first interoperable and openly accessible European data processing ecosystem. In the IPCEI-CIS conglomerate each institute and company has its own project. The project KICKS4EDGE by Siemens is part of one out of four IPCEI-CIS-workstreams which is focussing on "Advanced Applications". The project started in February 2024 and supports the development of an open industrial edge technology stack, which is device and cloud agnostic.

The overall project goals are:

- Enabling companies, in particular SME's, to digitalize their production and processes with CEI technologies.
- Providing open interfaces with device- and cloud-agnostic modular systems.
- Demonstrate the benefits of openness within the cloud-edge ecosystem with SAP (GER), Deutsche Telekom (GER), Fincantieri (IT), MONDRAGON Corporation (ES), Phoenix Systems (PL).

5 https://www.bmwk.de/Redaktion/EN/Artikel/Industry/ipcei-cis.html

Although CEI technologies have great potential for decentralised data analysis and the digitisation of production processes across industries, it is often difficult to realise this potential because of the practical requirements of industry sub-sectors or use cases. In addition, requirements can change, for example due to necessary technical integrations or legal reasons. Accordingly, the project follows an agile approach in which industry requirements are constantly tracked and taken into account in the project's efforts to support cross-domain harmonisation of requirements for edge cloud systems. In this context, not only the requirements from the manufacturing subdomains in which Siemens is active are monitored, but also those from partners within the same IPCEI-CIS workstream ("Advanced Applications") on asset verticals (e.g. Deutsche Bahn).

On this basis, Siemens aims to develop and integrate a compliant, open industrial edge software stack to improve connectivity and facilitate process orchestration. A software development kit (SDK) will be developed to enable users to create their own connectors and integrate available third-party hardware. The project will also address testing scenarios of applications before deployment on the shop floor with dedicated tools and device tests. This automated testing approach directly assesses aspects such as functionality, safety and security. Once these tests have been passed, using not only simulated but also real historical data from digital twins, the software solution can be deployed on the shop floor.

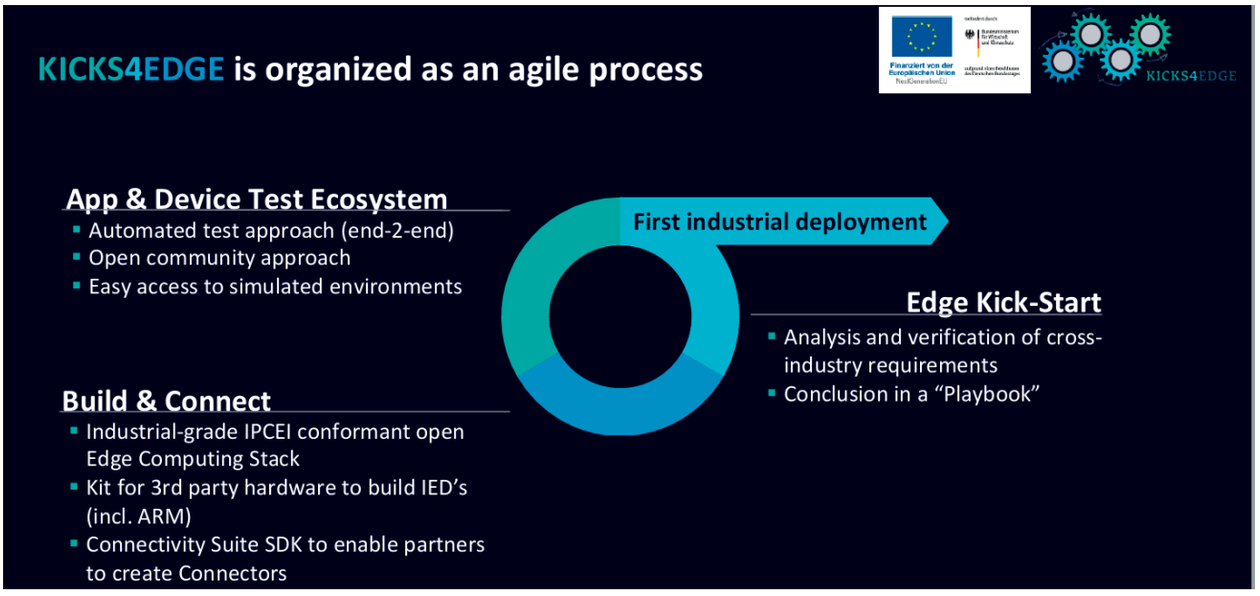

Figure 3: Contents and focus of of KICKS4EDGE project

However, the KICKS4EDGE project will also place particular emphasis on analysing the actual technology uptake of CEI solutions by small and medium-sized enterprises (SMEs). In this context, workshops will be organised for companies interested in industrial edge applications and their benefits for the digitalisation of the shop floor. The workshop programme will start in the summer of 2024 and will be specifically targeted at SMEs. Companies that attend a workshop can then apply for a Siemens starter kit to test the respective CEI technologies and applications on their shop floor. During this phase, Siemens will provide around two days of initial technical support to help companies digitise their shop floor themselves.

The results of the workshops and application tests are expected to provide Siemens with valuable insights into the specific needs of SMEs, as well as promising service and business application offerings for SMEs. In turn, potential success stories from these efforts could not only act as a catalyst for technology adoption by SMEs, but also be highly useful for future marketing activities for Siemens products.

2.3.3 Innovative Solution: DRIMco

DRIMco is a young and innovative German company. The initials "DRIM" stand for "digitalized requirement interface management system". The company provides AI solutions for the manufacturing, automotive and healthcare domain and holds 15 patents related to the underlying technological approaches.

The company is also active in funded research projects, e.g. leading a German funded research project on "open federated learning as a service", and in the field of scientific publication and teaching. DRIMco also adresses data-sovereignty explicitly within its platform. This means that industry data is processed in a privacy-preserving manner. The data does not leave the customer's premises.

DRIMco offers generative AI tools to analyze requirements, especially for product lifecycle management. An innovative service is 'AI-assisted requirements analysis', which can automatically generate compliance reports based on tender specifications to speed up tender analysis, regulatory analysis and help reduce risk costs. Manually identifying the requirements from an invitation to tender, from a request for proposal (RFP) or from a request for quotation (RFQ) is a very time-consuming task, typically involving reading thousands of pages. The same applies to the subsequent task of reconciling actual requirements with internal business documents to ensure compliance.

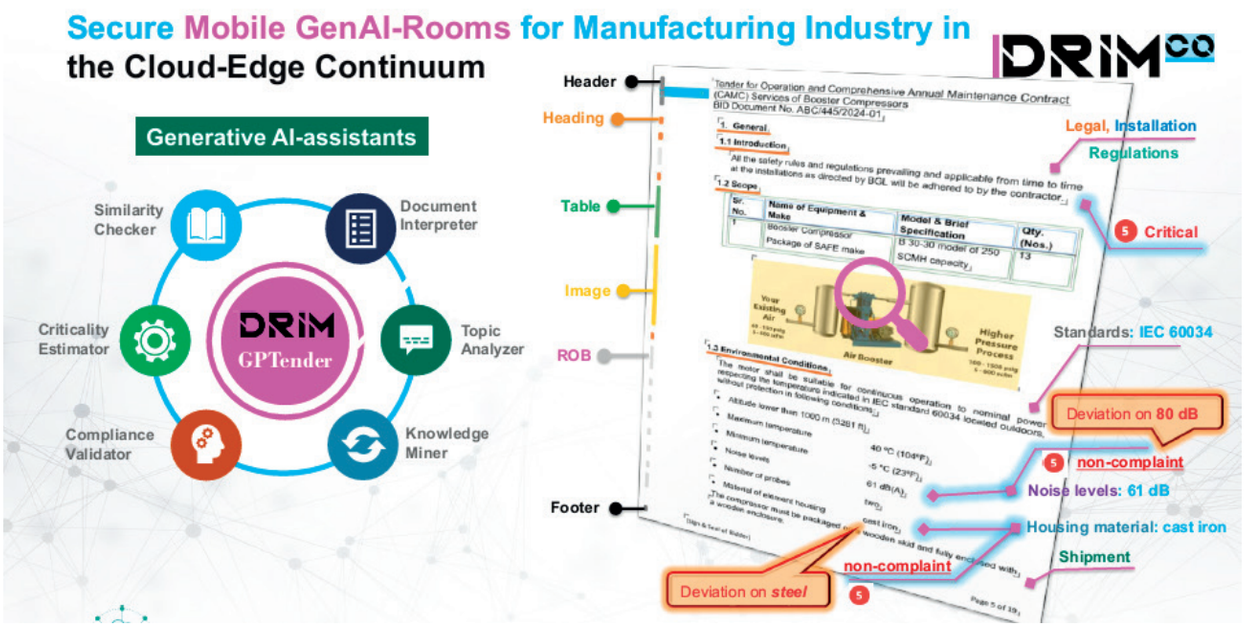

Figure 3: Working Principle of DRMco's AI Based services for requiremnt analysis

Using AI, manual tasks related to requirements analysis or quality assurance can be automatically distributed to different roles or personas with relevant expertise, such as legal, technical or business know-how. A so-called compliance matrix is created to document the compliance with the relevant requirements. Non-compliant requirements are identified, for example if a supplier is unable to meet a particular requirement. This is critical, as failure to meet one of these parameters can lead to high risk costs or penalties in the execution of tenders. This risk can be significantly reduced by using proactive analysis to distinguish between compliant and non-compliant requirements.

The underlying large language model GPTender was actually developed by DRIMco and automatically analyzes requirements from tenders and regulations. However, GPTender does not only represent a language model, but also a generative AI action agent that produces reports about compliance and non-compliance with requirements. Users can ask questions and receive

relevant answers, including potential root causes and historical impacts. DRIMCO's GPTender also proposes solutions to deal with non-compliant requirements and extracts relevant information from documents, such as applicable standards. Accordingly, DRIMCO aims to enhance compliance management and optimize bidding and execution processes with its solutions.

The DRIMco software products can be connected via REST APIs to augment functionality in application-lifecycle management (ALM) and, in particular, product lifecycle management (PLM) software. Siemens software (e.g., Polarian, Teamcenter) is already compatible and future connectivity is planned with various workflow management systems (e.g., Jira, Salesforce, Mitchell, SAP).

3 Conclusions and observations

The current digital transformation of manufacturing, and in particular the incorporation of CEI technologies, offers enormous opportunities for European companies in the manufacturing sector. Data-driven business models and the data economy offer promising prospects, while US-based hyperscalers are currently trying to disrupt European markets. However, the advantage that many European companies have in being deeply rooted in the manufacturing sector, and the growing consensus that many challenges can only be met through joint efforts, offers a perspective.

The discussed innovative solutions support the adoption of CEI technologies in manufacturing and showcase the market pathways taken by the companies involved:

Contact Software: Flexible and intuitive platform relying on open standards and interfaces

- **Added benefit:**
  - IoT and digital twin platform: "Elements for IoT" universally applicable in cloud, data centers or company networks with full functionality.
  - Flexible process integration and intuitive customization (e.g. functionality, architecture, access) by end users avoiding vendor lock-in.
  - Supporting data-driven business models for "smart factories" and "smart products" with data exchange across companies: e.g. between machine and component manufacturers and machine operators.
  - Analytics: Allowing for flexible customization by end user (low/no code) and own or 3rd party code integration .
  - Digital twin: Asset Administration Shell (AAS) part of standard product.
- **Risk:** Dependency on partnerships with hyperscalers to supply cloud services and infrastructure

Siemens: Edge hardware and horizontal architectures

- **Added benefit:**
  - Industrial Edge platform: orchestration of manufacturing process with full data sovereignty
  - Industrial Edge Software: Siemens software, own code and 3rd party software of certified partners.
  - Focus on building digital twins around products, production, and in-service processes
  - Valuable insights into specific requirements of SMEs could be a catalyst for CEI technology adoption by SMEs.
- **Risk:** Dependency on partnerships with hyperscalers to supply cloud services; Industrial Edge / management platform with certain limitations for self-customization by end users (adaptations are paid service, only 3rd party software of certified partner)

DRIMco: Generative AI tools to analyze requirements

- **Added benefit:**
  - Efficient Requirement Analysis: DRIMco's generative AI tools automatically generate compliance reports.
  - Data Sovereignty: Possibility of on-premise operation.
  - Easy and intuitive usability of services.
  - Flexible Integration with Industry Software.
  - Technological souvereignty and intellectual Property: Own LLM and numerous patents
- **Risk:** While DRIMco aims to enhance compliance, it must also ensure its own adherence to legal and regulatory frameworks. Failure to do so could result in legal penalties or reputational damage.

All three company examples address data sovereignty in their solutions and provide interoperability for commonly connected systems. All three solutions address openness, albeit to a slightly different extent. Of course, the choice of degree of openness is closely related to market position, established business models and market dependencies.

In the manufacturing sector, a diverse ecosystem of companies is actively contributing to innovation and networking around CEI. However, this also highlights the increasing importance of harmonising CEI solutions, a focus of initiatives such as IPCEI-CIS or national programmes such as Germany's Manufacturing-X initiative[6]. For practical implementation, the harmonisation of requirements and the acceptance of CEI solutions by SMEs is crucial, which is in line with the objectives of the IPCEI-CIS project "KICKS4EDGE".

Given the growing influence of US hyperscalers on the market, the European strategy of establishing data-space architectures that explicitly respect the principles of sovereignty offers a promising perspective. Developments in recent years show that even the European "big players" in this field are willing to adapt their established business models and allow certified third-party service providers access to their ecosystems. This is not only a result of regulation (e.g. Digital Market Act, Data Act), but also a direct consequence of the changing market situation. Data-driven and AI-based services from US companies currently have a huge potential to disrupt European markets.

European open ecosystems, which allow the flexible integration of specialised data-driven services by providing interoperability and valuable data sovereignty, could provide a strong alternative to the monolithic solutions of the hyperscalers. However, given the potential of these companies, this will require an intensification of strategic cooperation between the relevant large and smaller companies in Europe to test and evaluate the emerging novel solutions and platforms.

6 https://www.bmwk.de/Redaktion/EN/Dossier/manufacturing-x.html

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