Industry 4.0 –
What does it Mean for CAPIEL Manufacturers?

1 INTRODUCTION

Manufacturing industry has entered in a new phase of changes, which foresee digital technologies to be integrated within the heart of industrial processes.

This fourth industrial revolution is giving birth to a new generation factory: called "Cyber-factory", "Digital Factory", "Smart Manufacturing", "Integrated Industry", "Industry of the Future", “Industrial Internet of Things” or "Industry 4.0", this technological shift offers an extraordinary field of innovation, progress and growth.

Industry 4.0 promises to be an industrial revolution in all aspects of manufacturing. Safe and secure automation, connectivity and smart applications will be key elements of the factory of the future, and influence all parts of the supply chain, from manufacturing of components up to delivery of products to customers, associated services and end of life management.

Industry 4.0 will support the creation of energy efficient machines, an optimized and reconfigurable manufacturing infrastructure and new business ideas in the area of service offered to customers. Ultimately, Industry 4.0 will yield increased productivity and flexibility to all players in the value chain.

CAPIEL products will be key elements of an Industry 4.0 architecture where sensors, automation controllers and actuators communicate in an industrial network.

This trend towards increasingly connected and “intelligent” low voltage devices will put new requirements on our products, on their “digital twins”, on our value chain and on our competencies in order to satisfy the demands of our customers.

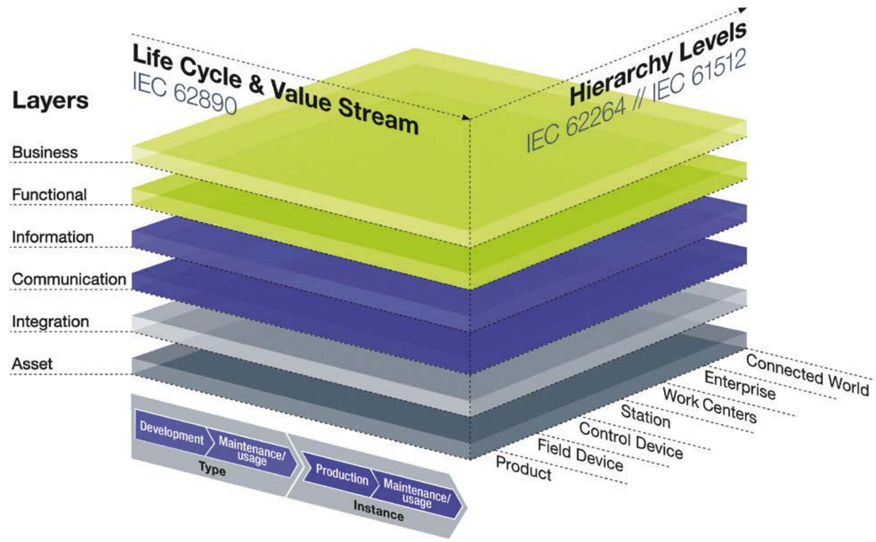
The intention of this document is to summarize the main consequences of this development: impacts on our products, on the associated data, on our operational processes and on our competence development.

In our analysis, we took a customer perspective while investigating the impacts: if our customers start using Industry 4.0, what requirements will they ask us to implement?

2 THE REFERENCE ARCHITECTURE WE HAVE ANALYZED: RAMI4.0

Several architecture models exist in the field of Industry 4.0; CAPIEL has chosen RAMI4.0 for the analysis, the model created by the German Industry 4.0 initiative.

You can find more about RAMI4.0 here: http://bit.ly/1IzSBKC



The model is composed of three dimensions:

1. Hierarchy levels of an automation system.
   You find CAPIEL products on the lower levels: product, field device, control device.

2. Life cycle & value stream.
   CAPIEL products are present
   - as "digital models" (*product types*) in the engineering designs of our customers, e.g. as 3-D models or schematic symbols
   - as physical objects (*product instances*) when the customer installs or uses them

3. Layers.
   CAPIEL products have different representations in different contexts: during engineering, when they are integrated into systems (e.g. a control panel, automation systems), for fieldbus communication or as business articles e.g. during procurement.

We analysed the main impacts on CAPIEL manufacturers in steps:

- First, we gathered *customer* requirements that come from the three dimensions of the model.
- In a next step, we mapped the consequences of these requirements to the products, operational processes and future competencies of the *CAPIEL manufacturers.*
- Finally, we identified challenges that CAPIEL manufacturers may face.

3 IMPACT ON OUR PRODUCTS

Regarding our products, we see a demand for more specialized and more intelligent products, often equipped with communication features and software.

The products need to be accompanied by their “digital twins” for different layers and lifecycle phases.

Customer requirement	Main impact for us	Challenges for us
Customers will expect more specialized products for their application: the number of product variants will increase. Customer behavior of consumer business will affect industrial goods business.	• We need to implement customer specific product variants.	• We need reference product platforms, which allow customization of many parts cost-effectively.
Customers expect more intelligence in our products.	• Our product needs to be flexible regarding their functionality. • Our products need more features to monitor and record their own condition and the condition of the application they are controlling. • Our intelligent products should record data on their operation and of the application they are controlling. • Our products need to deliver monitoring data (e.g. voltage and current), more often using larger bandwidth. • Our products fit into standards-based distributed systems controlling a variety of devices.	• We need to manage product configurations consisting of hardware, firmware, PC software fitting together (versions, updates, …) • We need to implement and maintain engineering and configuration standards like FDI or FDT. • More communication bandwidth for gathering, accessing & analysing data from the products will be needed. • We need to provide access to standardized robust industrial, IT and cloud networks that occur seamless to users.
Customers want to use digital models of our products in their processes and want to reuse already entered data independently from the used tools.	• We need to provide relevant standardized data (CAD/CAE, electrical data, functional safety, functional behavior, HMI representation, etc.) of our products, communicating or purely electro-mechanical	• We need to push data model standards in order to simplify handling of different CAD/CAE data formats and tools. • We need to improve the quality level of the data models and tools offered to the customer. • The digital models need to be always up-to-date over the entire lifecycle.

Customers are requesting data for life-cycle assessments in order to evaluate the environmental impact.	• We need to provide data on the environmental impact of the products, e.g. PEP Eco passport ISO20140-5 or IEC 62474	• There are several different solutions how to solve this along the entire supply chain. • The complexity of managing the required information will need an IT solution.
Customers want to have the product conformance and compliance during the whole life cycle of his installation.	• The product specifications and other documentation need to be provided as agreed with the customer. • Our products need to maintain a unique identification (serial number) in the cloud, for example using QR code or other tagging.	• We need to manage product instance data for a huge amount of individual products. • We need to determine how to exchange compliance data for products (e.g. RoHS, REACH,…) between our suppliers, ourselves and our customers.
Our products need to have communication based on internet protocols for private (intranet) or public networks (e.g. the web).	• Standardized communication protocols and connectivity are necessary. • Our components need to be integrated into proprietary or standardized automation engineering tools.	• We need to equip our intelligent products with sufficient cyber security measures including certification if they are connect to a larger network. • We need to provide detailed information regarding our security measures. • We need to offer support for many different engineering tools. • We need to adapt the interfaces to be able to manage higher connectivity.

4 Impact on Operational Processes

As our customers are striving for reduced time to market, enhanced flexibility and increased efficiency, we need to be prepared and streamline our organizations to handle these needs.

Consequences are wider product variability, capability to identify and track products along their lifecycle, eCommerce possibilities and a greater demand for technical consulting and support.

Customer Requirement	Main Impact for us	Challenges for us
Customers will expect more specialized and even customized products for their application.	• We need to implement customer specific production (e.g. printing, additive manufacturing), maybe lot size one.	• New production methods (additive production, collaborative robots,…) may be needed. • We may need sophisticated planning/MES software for better flexibility towards customer demands. • We must be prepared to dealing with complexity from design to production, including product life cycle and supply chain.
Customers want to reduce cycle times and stock levels. More fully automated logistic systems will be used.	• Our products need deterministic lead times. We might need to make our supply chain visible and provide current data on it. • We need possibilities for electronic ordering, invoicing, … • Detailed logistic data for each package unit is requested. • Logistic concepts like Just-in-Time or Just-in-Sequence become more relevant for us.	• Our eBusiness capabilities need to be very flexible to be compatible with a lot of different business systems. • We need to adopt our internal company structure in order to support the customer at all stages of the supply chain.
Customers expect detailed traceability data for each individual product.	• We need to track composition, production data, test data of each individual product and record it per shipment.	• Link real world (SCM) with digital world (PLM) – consistent databases will be very important.
Customers will buy solutions instead of products. Customers expect a higher level of technical consulting and support.	• We need to strengthen our cross-functional expertise. • Trial installations with customers can help to optimize simplicity and user effectiveness. • We must manage the transformation from largely	• We need to provide a wide area of pre- and after sales support (documentation, web presence, call centres, training, etc.) • Barriers between different parts of our organization need to be reduced or removed.

	manual-oriented work towards system engineering and automatic processes.	
Customers expect a digital integration of the value chain: ordering, tracking, payments,…)	• Our SCM capabilities need to be very flexible to be compatible with a lot of different business systems	• Need standardized interfaces to support different customer business systems and business models • The sales channel landscape (manufacturers, distributors,…) might change with upcoming new players or the elimination of intermediaries.
Customers expect guided selection of products, e.g. with configurators.	• We need to manage dependencies between different products, based on the system or aggregate need of the customer.	• Need an additional layer of data management depending on the system configuration.
Customers require ethical and environmentally responsible supply chain management.	• We need to manage the traceability of our suppliers.	• Push digital means of managing suppliers of on-compliant and counterfeit products • Handling of various Codes of Conduct from different parties.

5 Impact on Competencies

The shifts in product technology and operational setup will require an adoption of our competencies. In addition to electromechanical expertise, we need to advance our capabilities in the fields of electronics, embedded software, communication and IT.

Also new ways of interacting with customers will be a key element.

It may be difficult to recruit people that understand our "electrical" domain of the present as good as the new information and communication technologies of the near future.

Main Impact for us	**Challenges for us**
• New marketing techniques and innovative ways of managing the business using e.g. cooperation.	• Make use of social networks and new ways of communicating with customers
• We need staff on a higher education level to handle new technologies in R&D, applications and production. We can expect a shift to more software and IT. • We need a workforce with state-of-the-art hardware and software expertise.	• These competencies might be not widely spread in our existing staff. • Need new forms of recruitment and training will show up.
• New service-based economy open to smaller companies.	• Competition can come from start-up companies.

6 Standardization Landscape

Manufacturing is currently including a wide range of proprietary, non-interoperable systems. In addition: in a more globalized world, machines are moving over continents and their components may be sourced globally.

In order to ensure global usability and cross-system interoperability, international standardization in the industrial domain is a priority. It is required especially for integrating new technologies such as the Internet of Things, digital data models, and for the integration of technical and business processes.

The main international standardisation bodies actively developing the Industry 4.0 system standards are:

- ISO TC 184 SC4 - Industrial Data
- ISO TC 184 SC5 - Interoperability, integration, and architectures for enterprise systems and automation applications
- IEC TC 65 - Industrial-process measurement, control and automation
- IEC TC121 - Switchgear and controlgear and their assemblies for low voltage.

Main themes in the standardization work are:

1. Enterprise Structure: Companies are structured by
    - hierarchy levels: IEC 62264 - Enterprise-control system integration
    - life cycle: project IEC 62890 - Life-cycle management for systems and products used in industrial-process measurement, control and automation
    - IEC 62794 - Industrial-process measurement, control and automation – Reference model for representation of production facilities (Digital Factory)
    - IEC 62832 - Industrial-process measurement, control and automation – Digital Factory framework
2. Interoperability and common generic product data models
    - IEC Component Data Dictionary (IEC CDD) with IEC 61987 for automation and process control devices and IEC 62683 for switchgear and controlgear. It consists of describing a family or type of similar product "classes" using a set of standardised properties. These standards help identifying classes and properties uniquely, and naming and defining them unambiguously.
    - The consortia eCl@ss and ETIM provide hierarchical classification systems for grouping products, and they are working together to get to a common mapping. There are using IEC CDD as a master database for the available properties.
    - IEC 62424 - Representation of process control engineering – Requests in P&I diagrams and data exchange between P&ID tools and PCE-CAE tools
3. Integration of products into automation systems
    - IEC 62541 - OPC Unified Architecture
    - IEC 62714 - Automation ML
    - IEC 61499 - Function Blocks for Industrial Process-Measurement and Control Systems
    - IEC 62453 - Field Device Tool FDT
    - IEC 61804 - Electronic Device Description Language EDDL
    - IEC 62769 - Field Device Integration FDI

7 CONCLUSIONS

From a helicopter perspective, three main areas of digitalization show up:

- Digital integration of the **product life cycle** with the demand for data models or "digital twins" of products for product development, production engineering, production and maintenance.
- Digital integration of the **value chain** with requirements to improve eBusiness capabilities
- **Smarter products** with the ability to communicate with each other and with remote databases ("The Cloud") on all levels of the automation pyramid.

Many of the development activities take place in standardization and industry associations; therefore, some level of multi-vendor compatibility and cross-sector agreement is like to occur.

CAPIEL manufacturers should closely monitor these developments, and prepare their offering, their operational processes and their competencies in order to keep pace with these trends.

8 Glossary

Architecture	Specific configuration of elements and models in a system built on principles and rules for the purpose of its construction and use.
Life Cycle	Evolution of a system, product, service, project or other human-made entity from conception through retirement. Alternative: consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to the final disposal Source : ISO 14040
Model	Coherent and sufficiently detailed abstraction of aspects in an application area.
Product data model	conceptual model that describes a specific organization of product data to provide communication for a given application context Source: ISO 10303-1, 3.2.21 (modified)
Digital Twin	The set of digital models that represent a product in all aspects of its life cycle.
Reference Architecture	Model of an architecture description, which is commonly used and accepted as suitable.
Security	Condition of the system being protected from unintended or unauthorized access, change or destruction. Note: Security is a property of a system by which confidentiality, integrity, availability, accountability, authenticity, and reliability are achieved.
Internet of Things	The *Internet of Things* refers to a virtual representation of a broad variety of objects on the Internet and their integration into Internet or Web based systems and services. Based on interaction and communication interfaces such as RFID, NFC, barcodes or 2D codes they expose information, features and functionalities that can be integrated into systems and services.

	(http://www.w3.org/WAI/RD/wiki/Internet_of_Things)
Interoperability	Property of a product or system, whose interfaces are completely understood, to work with other products or systems, present or future, without any restricted access or implementation.
Digital Factory	Digital representation of a production system. A Digital Factory can represent an existing or planned production system. (IEC62832)