Business Case Evaluation Methodology (BCEM) for Factories Digitalization

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Agenda

- *Introduction*
- *Holistic migration methodology advantages*
- *FAR-EDGE Business Case Evaluation Methodology (BCEM)*
- *FAR-EDGE Project use case 1: WHR*
- *FAR-EDGE Project use case 2: VTC*
- *Conclusion*

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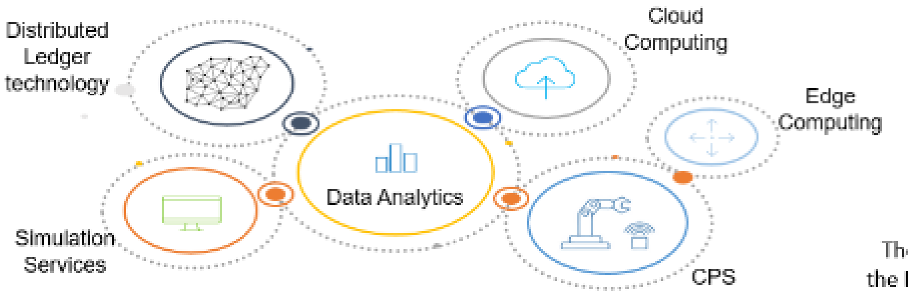
Introduction



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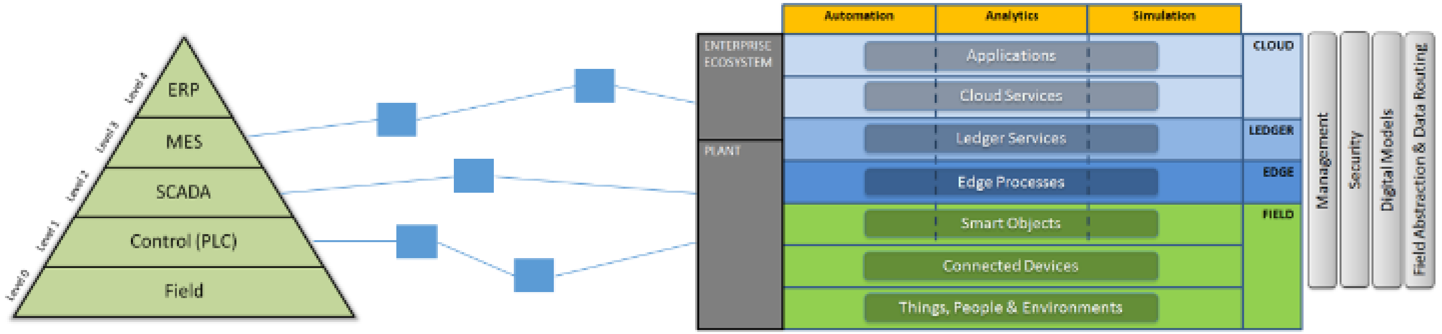

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Some existing methodologies

To develop a methodology able to identify, guide and evaluate migration paths for a specific business case towards holistic digital transformation

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BCEM for Factories Digitalization

Blueprint Migration

① Competitive differential in the company value chain
- SWOT analysis
- KPIs definition
- Porter's value chain revisitation

② Assessment
- Questionnaire: Technical, Operational, Human dimension
- Collaboration with use case experts
- Migration matrix preparation
- AS-IS scenario definition

③ Migration scenarios
- Collaboration with OEMs and solution providers
- TO-BE scenario definition
- Migration matrix completion

④ Gap Analysis
- Required components
- Possible integrations
- Steps for application

⑤ Value Added identification
- KPI improvements estimation
- Unmeasurable advantages evaluation

⑥ Economic Analysis
- Economic KPIs estimation
- Cost estimation
- Economic appraisal

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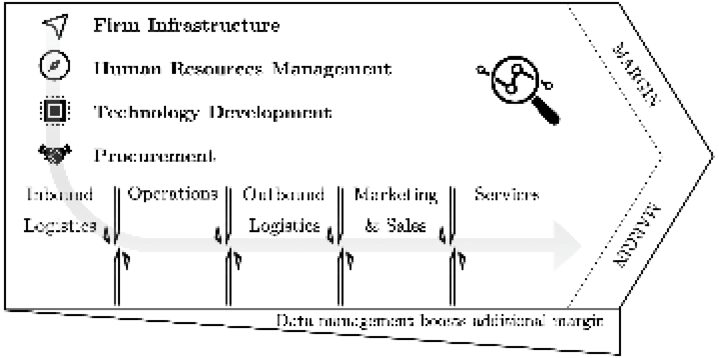
BCEM – step 1

① **Competitive differential in the company value chain**

- ✓ SWOT analysis[1]
- ✓ KPIs definition
- ✓ Porter's value chain[2]



- ➢ **The first step of the methodology aims to open the way toward digital transformation. This section contains only dynamic tools which should be updated periodically, as the environment continuously change also the company should continuously adapt and take advantage of it.**
- ➢ **A strict subdivision of the primary activity must be overcome. Standardization of the data management architecture should be able to break the barrier of the primary activity, making data available through all the factory activities.**

[1] *E. Gürel. Swot analysis: A theoretical review. Journal of International Social Research, 2017.*
[2] *M. Porter Competitive Advantages, Creating and sustaining superior performances, 1985.*

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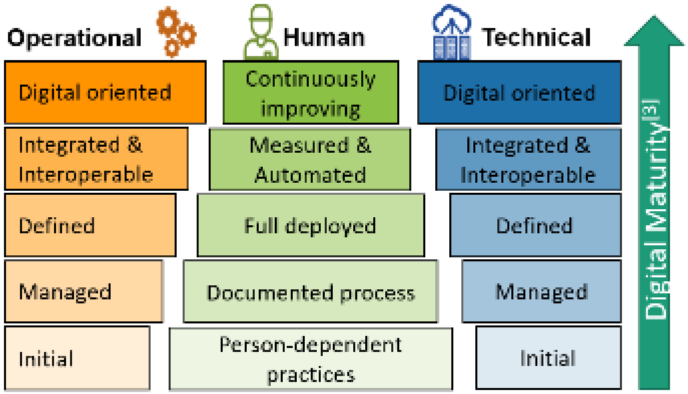
BCEM – step 2

② **Assessment**

- ✓ Questionnaire: Technical, Operational, Human dimension
- ✓ Collaboration with use case experts
- ✓ Migration matrix preparation
- ✓ AS-IS scenario definition



- **The main goal of this assessment is to clearly define the AS-IS situation in the technical, operational and human dimension.**
- **The three-dimensional structure has been adopted to offer a holistic migration, not only technical-centred. No dimension is independent from the others, thus it would be a substantial mistake to consider the enhancement in a certain issue, without considering the effect on the others.**
- **To assess the various issues related to the three dimensions a maturity model has been exploited.**

[3] *G. Schuh, R. Anderl, J. Gausemeier, M. ten Hompel, and W. Wahlster. Industrie 4.0 Maturity Index - Managing the Digital Transformation of Companies. acatech STUDY, 2017.*

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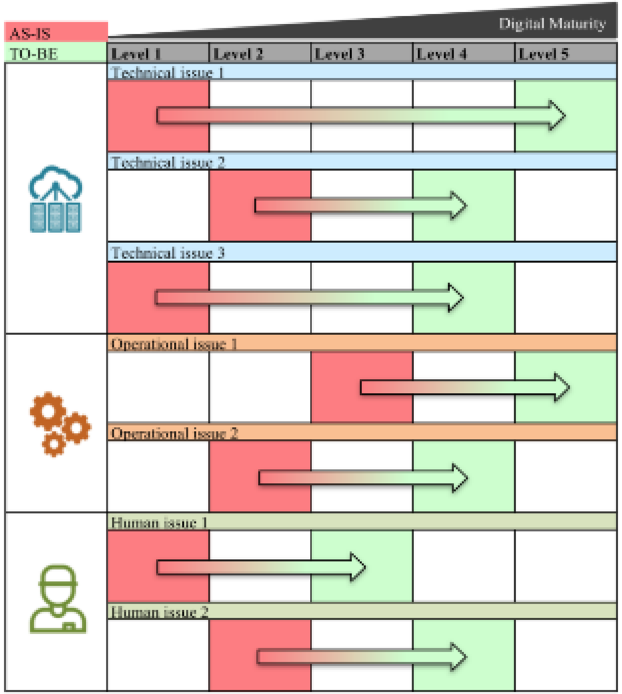
BCEM – step 3

③ Migration scenarios

- ✓ Collaboration with OEMs and solution providers
- ✓ TO-BE scenario definition
- ✓ Migration matrix completion



- **There could be more than one way to reach the desired result and the TO-BE scenario could not be unique.**
- **The possible scenarios depend on specific information which should be researched in collaboration with solution providers.**
- **A collaboration with OEMs and solution providers is required at this point in order to assess the feasibility of the scenarios and provide solutions able to improve the KPIs defined in step 1.**

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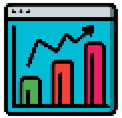
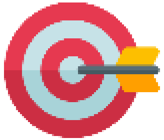
BCEM – step 4 & step 5



④ Gap Analysis

- ✓ Required components
- ✓ Possible integrations
- ✓ Steps for application



⑤ Value Added identification

- ✓ KPI improvements estimation
- ✓ Unmeasurable advantages evaluation

- ➢ **Also the gap analysis between the AS-IS and the TO-BE scenarios represents an outcome of the collaboration with the solution providers.**
- ➢ **Required components, possible integrations and steps for application are the three main steps to carry on.**
- ➢ **The improvement KPIs refer to the measurable performance of the systems, not to a business economic goal**

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BCEM – step 6

⑥ **Economic Analysis**

- ✓ Economic KPIs estimation → *From performance improvement to €/year*
- ✓ Cost estimation → *TCO model for on premise application* [4]
- ✓ Economic appraisal → *Discounted Cash Flow method* [5]

- **A cost-benefit analysis to justify the investment in digital transformation is the last step of the methodology.**
- **This analysis is performed in a differential way comparing the TO-BE situation with respect to the AS-IS situation.**
- **If the analysis is performed in a correct and meaningful way, subtracting benefits and costs from one another, it becomes clear which situation is preferable from a profit perspective.**

[4] *M.S. Grobelny. Evaluating the Total Cost of Ownership for an On-Premise Application System, 2017*

[5] *G. Azzone, U. Bertelè. L'impresa - sistemi di governo e valutazione, 2017*

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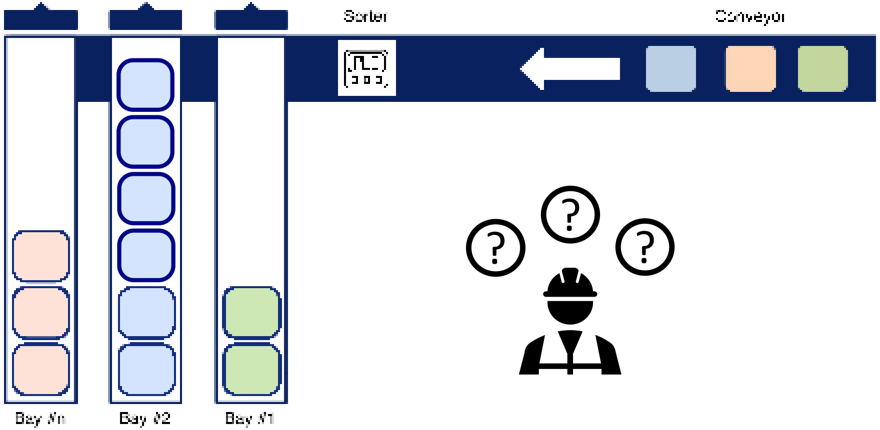
BCEM – use case 1

AS-IS scenario



SWOT Analysis

Internal factors	Strengths	• ISA-95 automation pyramid integration (ERP, MES, SCADA) • Solid competences developed in many manufacturing factories worldwide • Internal digital knowledge in others Industry 4.0 research projects
	Weaknesses	• Sorting system unreliability (production stoppages, hardware problems) • Sorting system rigidity (long reconfiguration time)
External factors	Opportunities	• FAR-EDGE improves system flexibility, adaptability (Plug'n'Produce) and reliability • Lead the digital transformation disruptive trend • Creation of a standardized architecture shared with the acquired Indesit factories
	Threats	• Architecture changing projects require long time to observe useful results • Digital projects applied to big companies are very expensive • Lack of widespread competences about Edge Computing and Distributed Ledger

✗ Sorter unreliability

✗ Sorter rigidity

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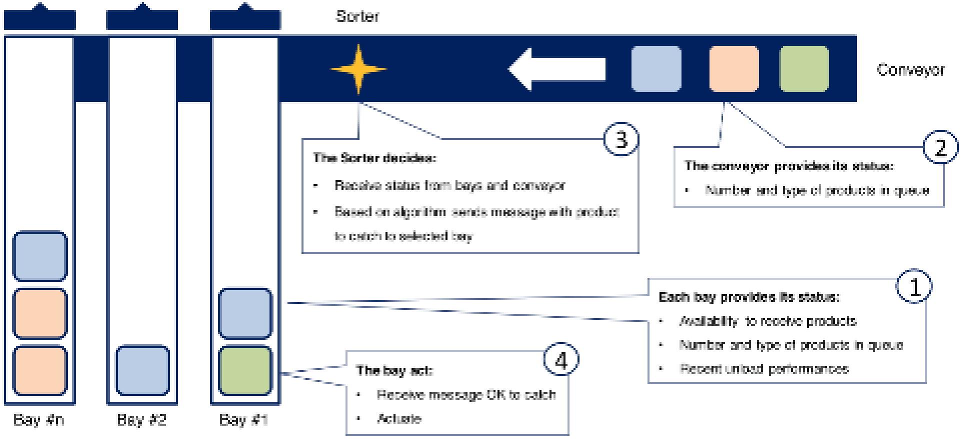
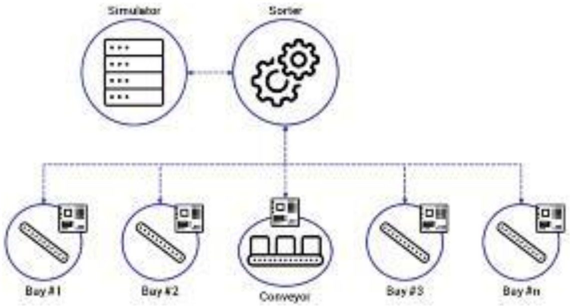
BCEM – use case 1

- TO-BE scenario
- KPIs:
  - ✚ OEE
  - ✚ Reconfigurability





- Qualitative impacts:
  - ✚ Improved dispatching policy
  - ✚ Operators' stress relief
  - ✚ Field-simulation model synchronization
  - – Complication of the IT system
  - – Specific technical skills required

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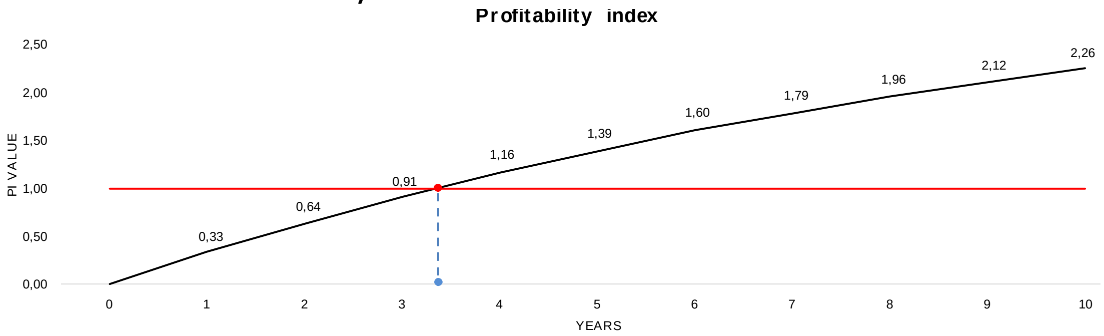
BCEM – use case 1

Steps for application

1. OEMs research
2. Design and implementation of the Edge computing and the Ledger infrastructure
3. Design of the simulation model + field synchronization
4. Testing
5. Training of the operators and IT department for operative and maintenance purposes

Economic Analysis



$$PI = \frac{\sum_{t=1}^{T} \frac{CF(t)}{(1+k)^t}}{I(0)}$$

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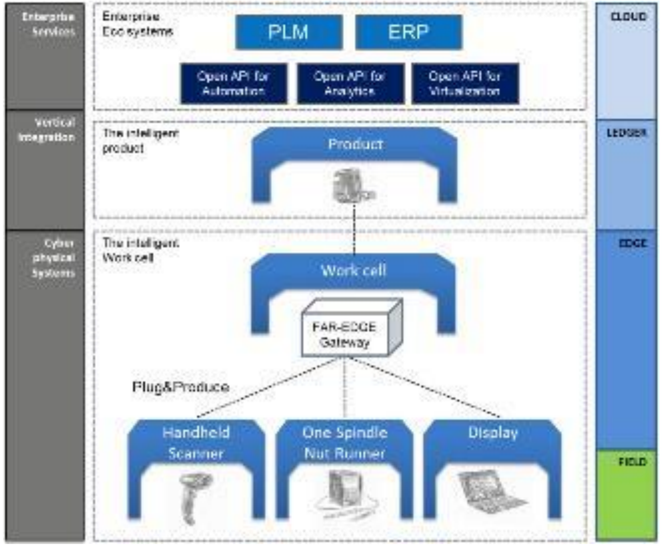
BCEM – use case 2

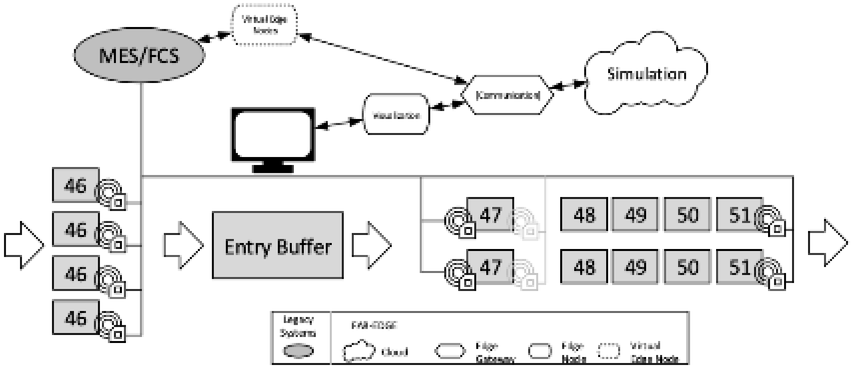
UC#1 – Plug'n'Produce of a Nutrunner Automatic Re-Configuration



Main impact on:

- Tools adaptation time
- Rework rate

UC#2 - Operator Support for Smart Sequencing



Main impact on:

- System throughput
- Reduction of penalties

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BCEM – use case 2

FAR-EDGE

MP 1 Automation	Level 1	Level 2	Level 3	Level 4	Level 5
	Equipment/Machinery connectivity and communication protocols				
	Not available	Basic connectivity (RS232-RS485)	Local network through LAN/WAN	Networked with vendor specific API, integrable with other systems	Networked with standardized mechanisms and standard API
	Physical production process control				
	Not available	Locally, per station / equipment	Centrally available through SCADA	Available and analyzed through MES at Factory level	Available and analyzed through the Cloud
	Cyber-Physical System characteristics of the product				
	No identification or serialization available	Simple identification (e.g. Barcodes or RFID tags)	Sensors and actuators attached to the product	Sensors readings are processed by the product	The product exhibits CPS functionality
	Reconfiguration of shop-floor equipment				
	Only manual reconfiguration	Supported by HMI at machine level	Configuration managed through central supervisor system	Configuration centrally managed by MES or MOM	Centrally managed according to ERP through the Cloud
	Production IT department				
	Not available	External service provider for traditional IT systems	Internal for traditional IT systems	External service provider for all digital systems from field to cloud	Internal for all digital systems from field to cloud
	Production employees' skills				
	No experience with digital technologies	Little experience with digital technologies	Digital skills in some technology focused areas	Digital and data analysis skills in most areas of the business	Cutting edge digital and analytical skills are prevalent all across the factory

FAR-EDGE

MP 3 Simulation	Level 1	Level 2	Level 3	Level 4	Level 5
	Devices connectivity capabilities				
	Not available	Basic connectivity (RS232-RS485)	Local network through LAN/WAN	Networked with vendor specific API, integrable with other systems	Networked with standardized mechanisms and standard API
	Simulation input data collection				
	Hypothesized according to professional role experience	Defined based on the system design parameters	Deducted by manual measurements	Deducted by statistical analysis based on historical data	Collected in real-time or near real-time from the field through sensors
	Production Optimization				
	Not available	Rare offline optimization	Offline optimization based on manual data extraction	Manual optimization based on simulation data	Automatic optimization based on simulation services
	Availability of production process models				
	Not available	Models defined (Excel based) with limited use	Models defined with limited specific functions	Models defined and integrated with business functions	Models defined and integrated with several different functions
	Impact of digital technologies on Product Designers and Production Engineers				
	Still unclear	Identified in general terms	Analyzed	Defined	Implemented in continuous improvement

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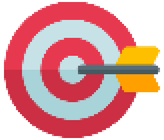
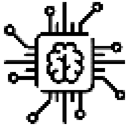
Conclusion

Even if the smart technologies implementation is becoming a paramount trend in the **manufacturing world**, the path toward I4.0 is often encountered several obstacles. **Possible barriers** regarding investments in digital transformation are represented by the difficulty of assessing and easily predicting the **tangible benefits** that this cultural and technological evolution can bring. For this reason they must be guided by **clear managerial objectives** and **quantifiable business benefits**.



The **impacts evaluation** of migration towards digital transformation can be a **useful tool** to identify and analyze the steps to be taken, trying to predict **risks** and **threats** and leveraging **strengths** and **opportunities**.



A **holistic** view must consider migration from the **technical**, **operational** and **human** point of view, trying to evaluate the potential tangible and intangible benefits.

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FAREDGE

Thanks for the attention!

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Insight

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BCEM – use case 1: matrix

Porter’s Value chain

- B2B process which adds value on top of transforming raw materials, delivering the product and providing services to the final user (e.g. product warranty)
- The particular use case impacts on the primary activity of
  - Operations: by making the final sorting system more flexible and increasing the system reliability.
  - Outbound logistics: by simplifying the collection of the pallet from the final bays with an improved sorting policy
  - Services: by making available the information about each bay content
- In general Firm infrastructure leads the digital transformation, Human resources guarantee proper training, Procurement assures services alignment with the novel architecture, and R&D develops the technologies.
- Data can move unbounded thanks to the NGAC.

MP 5 Automation Simulation	Level 1	Level 2	Level 3	Level 4	Level 5
	Sorter-bay connectivity and communication protocols				
	Not available	Basic connectivity (RS232-RS485)	Local network through LAN/WAN	Networked with vendor specific API, integrable with other systems	Networked with standardized mechanisms and standard API
	Information Access Points				
	Not available	Sensors' hardware	Centralized unit	Cloud level	Cloud and Edge levels
	Security and access control mechanisms				
	Not available	Locally, per station / equipment / machinery	Centrally available through SCADA	Available and analyzed through MES at Factory level	Available and set up through the Cloud
	3D layouts, visualization and simulation tools				
	CAD systems not related to production data	CAD systems manually feed with production data	CAD systems interfaced with other design systems	CAD systems interfaces with intelligent systems for fast development	Fully integrated CAD systems with intelligent tools for interactive design process
	Sorting-policy optimization				
	Not available	Operator or Scheduling engineer experience decision	Historical production data supported decision	Simulation supported decision	Autonomous simulation-based decision, Machine to Machine collaboration
	System reconfiguration				
	Manual operator reconfiguration	Reconfiguration of the single station / equipment (PLC)	Reconfiguration from a central supervisor system (SCADA)	IT central reconfiguration (e.g. MES or MOM)	Reconfiguration according to business requirements
	Maintenance department skills				
	No experience with digital technologies	Little experience with digital technologies	Technology focused areas have employees with digital skills	Most areas of the business have well developed digital and data analysis skills	All across the business, cutting edge digital and analytical skills are prevalent

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BCEM – use case 2: step 1

SWOT Analysis

Internal factors	Strengths	• ISA-95 automation pyramid integration (ERP, MES, SCADA) • Solid competences developed in many manufacturing factories worldwide • Internal digital knowledge in others Industry 4.0 research projects
	Weaknesses	• Ordinary non-optimized assembly line managing policies (no simulation support) • Manual tool configuration is time consuming and leads to assembly errors
External factors	Opportunities	• Simulation for system optimization (e.g., improved truck sequences) • Analytics for data awareness (e.g., more precise assembly activities time) • Automation for Plug'n'Produce purposes (e.g., improved reconfigurability)
	Threats	• Architecture changing projects require long time to observe useful results • Digital projects applied to big companies are very expensive • Lack of widespread competences about Edge Computing and Distributed Ledger

Porter's Value chain

- B2B process which adds value on top of transforming raw materials, delivering the product and providing services to the final user (e.g. product warranty)
- The particular use cases impact on the primary activity of
  - Operations: by assuring a correct tool parameters settings (UC#1); by shortening the tools set up time (UC#1); by optimizing the truck choice from the buffer (UC#2).
  - Outbound logistics: by reducing and simplifying the management of tardy deliveries (UC#2).
- In general Firm infrastructure leads the digital transformation, Human resources guarantee proper training, Procurement assures services alignment with the novel architecture, and R&D develops the technologies.

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BCEM – TCO model & Economic Analysis

	Design	Built	Deploy	Maintain	Upgrade
Cost Drivers	▪ Time and effort to identify business requirements ▪ Time and effort to design the infrastructure architecture ▪ Consultant fees for infrastructure design and planning	▪ Time and effort to assess and select hardware, software, and datacenter ▪ Time and effort to review license agreement, service level agreements (SLAs), and security requirements ▪ Software and hardware upfront costs	▪ Time and effort to setup, install, and test system ▪ Training for users and administrators ▪ Data migration related costs	▪ Time and effort to administer, manage, and support systems ▪ Hardware maintenance and software assurance ▪ Datacenter - power, cooling, space and internet bandwidth	▪ Time and effort to implement upgrades ▪ Infrastructure hardware and software upgrade costs ▪ Application software upgrade costs
	UPFRONT COSTS			RECURRING COSTS	

Assumptions for the economic analysis:

1. The appraisal is a differential analysis between the AS-IS and one TO-BE scenario at a time.
2. The evaluation period is 1 year, the number of periods is 10.
3. The investment is concentrated in the initial instant, at the beginning of the first period.
4. The investment has zero residual value at the end of period 10.
5. The discount rate is fixed and it is equal to 10%.
6. Unlimited budget: it is preferable to select the scenario which maximizes the NPV.
7. No depreciation or financing is considered: the project is completely financed by the company's own funds.
8. Scenarios are not necessarily mutually exclusive: the implementation of one scenario does not imply the certain exclusion of another in the future.
9. The project implementation is not compulsory: there is the possibility to maintain the AS-IS scenario
10. Sunk costs and sunk benefits are not considered.

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