General

ID[1]	
Use case name	Adaptable Factory
Application domain	Manufacturing
Deployment model	Cyber-physical System, Embedded System
Status	PoC
Scope[2]	(Semi-)Automatic change of a production system's capacities and capabilities from a behavioral and physical point of view
Objective(s)	The objective is to enable flexible production resources which enable fast reconfiguration and adaptation to changing situations, context, and requirements which facilitate optimized resource usage under uncertainty.
Narrative	Short description (not more than 150 words)	Rapid, and in some cases completely automated, conversion of a manufacturing facility, by changing both production capacities and production capabilities. This use case describes the adaptability of an individual factory by (physical) conversion and/or adaption of a factory's and its machines behavior in order to adjust to changing situations like disruptions, material quality variation, production of new products, etc. A prerequisite is a modular and thereby adaptable design for manufacturing within the factory. The result is a need for intelligent and interoperable modules that basically adapted to an altered configuration on their own, and standardized interfaces between these modules.
	Complete description	Use Case description taken from [1,2,3]. Plug & Play – using a home computer and a USB cable, it is easy to connect new devices and use them almost immediately without any additional effort. The flexibility that has been available for quite a while on desktop computers is now gaining importance for industrial production. Demands on adaptability of production infrastructure are already rapidly increasing. Shorter and shorter product and innovation cycles require investment decisions for new production facilities that reflect future demand for production and process changes, where possible. In addition, the growing volatility of orders is hindering the optimal utilization of manufacturing lines with increasing frequency. Flexibility and adaptability will become increasingly important criteria in decisions regarding construction and operation of new production facilities. One example is product labeling. Various printing technologies are available, for example tampon printers (transferring ink from the printing form to the product using an elastic tampon), inkjet printers and/or laser printers. In an adaptable factory this type of operating equipment can be connected directly to the automated production process. Simply put, the material to be printed says: "Print me", and the tampon printer will ask: "Is the material to be printed greaseless?" The ink jet printer will then ask about the material characteristics, because it uses heat for the drying process, for example. A laser printer will ask about the material receiving the label to ensure sufficient contrast.

Key aspects

The application scenario for adaptable factories describes the rapid, and in some cases completely automated conversion of a manufacturing facility, by changing both production capacities and production capabilities. The key concept for implementation is a modular and thereby adaptable design for manufacturing within the factory. Intelligent and interoperable modules that basically adapted to an altered configuration on their own, and standardized interfaces between these modules allow for quick and simple conversion to adapt to changes in the market and customer demands. Whereas the application scenario Order-Controlled Production emphasizes flexible use of existing manufacturing facilities by means of intelligent connectivity, this scenario describes the adaptability of an individual factory by (physical) conversion.

Today, when creating a production line, the focus is usually not only on quality, but also maximization of productivity and profitability of a pre-conceived product range. Individual components are connected statically and are capable of producing the pre-conceived functionalities and projected volumes. Frequently, a system integrator takes care of coordinating the individual components and developing a control system for the entire facility. However, if the order level is driven by strong product individuality or high fluctuation in demand, companies can no longer rely on the advantage of particular production lines. In this case, modular, order-oriented and adaptable manufacturing configurations become more attractive: For example, they increase overall utilisation or ability to deliver products. At the same time, however, the demands on individual machines or manufacturing modules increase. Even more important than high variance of specific manufacturing steps will be the ability to combine individual modules with ease and in any situation. In order to achieve this, the modules must contain a self-description regarding their ability to be combined or converted into a machine or plant very rapidly and robustly. The following examples illustrate these requirements:

- A new network-enabled field device, for example a drive with a new version of firmware, is hooked up to the production line. The new device must be provided automatically with network connectivity and be made known to all online subsystems. The participating systems must correspondingly be updated.
- An unconfigured field device is introduced to production, for example to quickly replace another defective device. The field device now must be individualized and parameterized due to the information located in the software components.
- A production facility is converted or modified because a new product variation is planned. The control and software related changes must be detected and automatically transmitted to all

		participating systems. • After conversion of a plant, it should be possible to move software components for process management around the decentralized control units, while observing certain criteria, such as output or availability. • A (new) function of the Manufacturing Execution System (MES) is inserted or altered, for example the visualization of a situation not previously required. The visualization should be done automatically and access to the necessary information from the field level should also be automatic. This requires the mechanical engineer to design the internal development processes accordingly. Modular machines require "modular" engineering, based on libraries of re-usable modules ("platform development"). Machine architecture must be designed such that combinable mechatronic modules are created, including the Plug & Produce capability of production modules using interoperable interfaces and adaptive automation technology. This requires development of concepts for "services" across manufacturer boundaries, such as archiving, alerting or visualising, as well as a low-cost integration of MES functions. **Effect on value chains** Value added is shifted from the system integrator to the machine provider or its supplier, because the machines or components are enhanced so that they are easier to integrate. The type and quality of system integration change. The present focus on (production) technology shifts to a stronger focus on organization and business processes related to production processes. In extreme cases, the system integrator could become obsolete if intelligent, self-configuring and interoperable manufacturing modules can be created at the level of the machine suppliers. **Value added for participants** For manufacturing companies, a quick, inexpensive and reliable conversion of manufacturing becomes possible, so that they can react quickly to changes in customer and market demands. Increasing standardization and modularization also expand the possibilities for combining manufacturing entities of various providers and therefore realizing the most economic solution for each individual module. Machine modularization opens up new areas with scale effects for machinery manufacturers.
Stakeholders[3]	Component suppliers (sensors, actuators), Machine builders, system integrators, plant operators (manufacturer)	
Stakeholders' assets, values[4]		
System's threats and vulnerabilities[5]		

Key performance indicators (KPIs)	ID	Name	Description	Reference to mentioned use case objectives
AI features	Task(s)		Automatic reasoning (e.g. [7,8]), AI (task) planning (e.g. [4,6]), distributed coordination and negotiation (e.g. [5])	
	Method(s)[6]			
	Hardware[7]			
	Topology[8]			
	Terms and concepts used[9]			
Standardization opportunities/ requirements	Standardization needs for setting up this use case is currently under further investigation. Some initial intentions on standardization needs are the following: a vocabulary with formal semantic for symbolic reasoning about production capabilities across different vendors, standardized negotiation mechanisms, standardized autonomy classes of components, machines, etc. Quality model for trustful learned models and automatic behavior resulting from it.			
Challenges and issues				
Societal concerns	Description		Enabling flexible and autonomously reconfigurable production systems ease human-machine configuration, facilitate optimized machine use, reduce failures through autonomous compensation, optimized product quality through prediction techniques.	
	SDGs[10]		Industry, Innovation, and Infrastructure	

Data (optional

Data characteristics	
Description	
Source[11]	
Type[12]	
Volume (size)	
Velocity (e.g. real time)[13]	
Variety (multiple datasets)[14]	
Variability (rate of change)[15]	
Quality[16]	

Process scenario (optional)

Scenario conditions					
No.	Scenario name	Scenario description	Triggering event	Pre-condition[17]	Post-condition[18]

Training (optional)

Scenario name	Training				
Step No.	Event[19]	Name of process/Activity[20]	Primary actor	Description of process/activity	Requirement

Specification of training data[21]	

Evaluation (optional)

Scenario name	Evaluation				
Step No.	Event[22]	Name of process/Activity[23]	Primary actor	Description of process/activity	Requirement

Input of evaluation[24]	
Output of evaluation[25]	

Execution (optional)

Scenario name	Execution				
Step No.	Event[26]	Name of process/Activity[27]	Primary actor	Description of process/activity	Requirement

Input of Execution[28]	
Output of Execution[29]	

Retraining (optional)

Scenario name	Retraining				
Step No.	Event[30]	Name of process/Activity[31]	Primary actor	Description of process/activity	Requirement

Specification of retraining data[32]	

References

References						
No.	Type	Reference	Status	Impact on use case	Originator/organization	Link

[1] Working Group on Research and Innovation of the Plattfom Industrie 4.0. Aspects of the Research Roadmap in Application Scenarios, Working Paper, German Federal Ministry for Economic Affairs and Energy, url: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/aspects-of-the-research-roadmap.html , 2016.

[2] Working Group on Research and Innovation of the Plattfom Industrie 4.0 and Alliance Industrie du Futur: Plattform Industrie 4.0 & Alliance Industrie du Futur : Common List of Scenarios. url: https://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/plattform-i40-und-industrie-du-futur-scenarios.html, 2018

[3] Communication Promoters Group of the Industry-Science Research Alliance and German National Academy of Science and Engineering. Recommendations for implementing the strategic initiative INDUSTRIE 4.0, Final report of the Industrie 4.0 Working Group, url: https://www.acatech.de/Publikation/recommendations-for-implementing-the-strategic-initiative-industrie-4-0-final-report-of-the-industrie-4-0-working-group, April 2013

[4] Christoph Legat and Birgit Vogel-Heuser. A configurable partial-order planning approach for field level operation strategies of PLC-based industry 4.0 automated manufacturing systems. Engineering Applications of Artificial Intelligence 66:128-144, DOI: 10.1016/j.engappai.2017.06.014,02017.

[5] Birgit Vogel-Heuser, Jay Lee, and Paolo Leitao. Agents enabling cyber-physical production systems. at – automatisierungstechnik 63(10).   DOI: 10.1515/auto-2014-1153, 2015.

[6] Jens Otto and Oliver Niggemann. Automatic Parameterization of Automation. Software for Plug-and-Produce. AAAI Workshop on Algorithm Configuration, 2015

[7] Christoph Legat, Christian Seitz, Steffen Lamparter und Stefan Feldmann. Semantics to the Shop Floor: Towards Ontology Modularization and Reuse in the Automation Domain. IFAC Processings, Vol. 47, Issue 3, pp. 3444 – 3449, Doi:10.3182/20140824-6-ZA-1003.02512, 2014.

[8] Martin Ringsquandl, Steffen Lamparter, Sebastian Brandt, Thomas Hubauer, and Raffaello Lepratti. Semantic-Guided Feature Selection For Industrial Automation Systems. International Semantic Web Conference. Springer, Cham, 2015.

Footnote

[1] Leave this cell blank.

[2] The scope defines the limits of the use case.

[3] Stakeholder involved in the scenario - examples are: type of organization; customers, 3rd parties; end users; humans; environment; negative stakeholders (attackers, criminals, etc).

[4] Assets and values that are valuable to the stakeholders and at the risk of being compromised by the AI system deployment – examples can include competitiveness; reputation or trust; fairness; safety; privacy; stability; etc.

[5] Threats and vulnerabilities can compromise the assets and values above. Examples are: different sources of bias; incorrect AI system use; new security threats; challenges to accountability; new privacy threats (hidden patterns).

[6] AI method(s)/framework(s) used.

[7] Hardware system used.

[8] Topology is the study of geometric forms differentiated by intersection and bifurcation. The term is used for the graphic aspects network architectures.

[9] Terms and concepts listed here can be used to extend the work of WG 1 (AWI 22989 and AWI 23053) as necessary.

[10] The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a collection of 17 global goals set by the United Nations General Assembly. SDGs are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.
See URL for more details: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html

[11] Origin of data, which could be from instruments, IoT, web, surveys, commercial activity, or from simulations.

[12] Structured/unstructured Images, voices, text, gene sequences, and numerical. Composite: time-series, graph-structured

[13] The rate of flow at which the data is created, stored, analysed, or visualized.

[14] Data from a number of domains and a number of data types. The wider range of data formats, logical models, timescales, and semantics complicates the integration of the variety of data.

[15] Changes in data rate, format/structure, semantics, and/or quality.

[16] Completeness and accuracy of the data with respect to semantic content as well as syntactical of the data (such as presence of missing fields or incorrect values)

[17] Describe which condition(s) should have been met before this scenario happens.

[18] Describe which condition(s) should prevail after this scenario happens. The post-condition may also define "success" or "failure" conditions.

[19] The event that triggers the step. This might be completion of the previous event.

[20] Action verbs should be used when naming activity.

[21] Training data can be further specified.

22 The event that triggers the step. This might be completion of the previous event.

23 Action verbs should be used when naming activity.

24 Specify input of evaluation.

25 Specify output of evaluation.

26 The event that triggers the step. This might be completion of the previous event.

27 Action verbs should be used when naming activity.

28 Specify input of evaluation.

29 Specify output of evaluation.

30 The event that triggers the step. This might be completion of the previous event.

31 Action verbs should be used when naming activity.

32 Retraining data can be further specified.