White Paper

Introduction to Industry 4.0

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Are you interested in production and manufacturing and the new concepts of Industry 4.0, then this whitepaper is for you. In the following three pages you will learn the basics about Industry 4.0, and you will understand how you and your organization can benefit from it. For a deeper understanding I recommend you to read some of the reference literature listed in the end of this whitepaper.

Industry 4.0 aims at advancing today's manufacturing

Industry 4.0 is sometimes referred to as the fourth industrial revolution, after the steam powered mechanical machines, the electrically powered mass-production, and the electronically/IT powered automated manufacturing. It focuses on the establishment of intelligent products and smart production processes, as well as on vertically and horizontally integrated manufacturing systems (see Figure with the four integration perspectives of Industry 4.0).

- Intelligent products: Smart products are uniquely identifiable, may be located at all times and know their own history, current status and alternative routes to achieving their target.
- Smart production processes: in an intelligent production process the various steps in the lifecycle (starting with the design phase and ending with the retirement phase), should be well integrated with each other.
- Vertical integration: vertically integrated manufacturing systems implies that the systems involved in the supply chain (from procurement to shipping) are integrated.
- Horizontal integration: horizontally integrated manufacturing systems implies that the systems involved in the supply chain (from procurement to shipping) are integrated

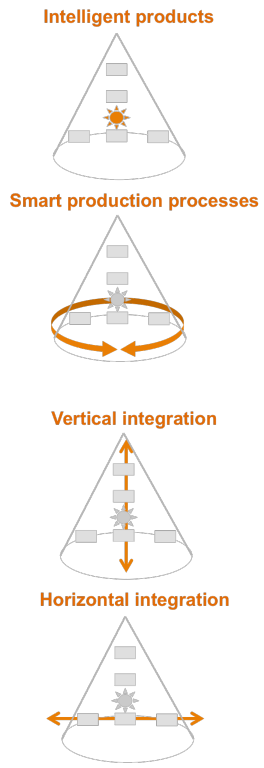


Figure: The four integration perspectives of Industry 4.0

Ultimately, Industry 4.0 should result in more rapid product development, facilitated customized production, improved handling of complex environments, faster supply chains, a more holistic life-cycle management, etc.

Industry 4.0 is originally a German initiative – are there other similar initiatives?

Industry 4.0 (German term: Industrie 4.0) is originally a German initiative with the aim of securing the future of German manufacturing industry. It is believed that Industry 4.0 will allow Germany to increase its global competitiveness and preserve its domestic manufacturing industry. Related research activities in Germany are currently supported by government funded bodies.

Yes, there are many other similar initiatives going on in various geographical areas and industry branches. A few of them are listed below:

- Internet of Things (IoT) refers to a world in which all everyday objects and devices are completely interconnected for seamless interoperability.
- Industrial Internet of Things (IIoT) is what you get when you apply the concepts of IoT to an industrial setting, e.g. to production.
- Smart Manufacturing is a term mainly used in the US.
- China2020 is a term mainly used in China.
- Factory of the Future is a large research initiative supported by EU, in which new technologies (such as IoT) should be applied to factories.
- Industrial Internet (General Electric), Connected Enterprise (Cisco), etc.
- Industrial Digitalization is a term used in Sweden and which stresses the impact and potentials of digitalization in both manufacturing and process industries.

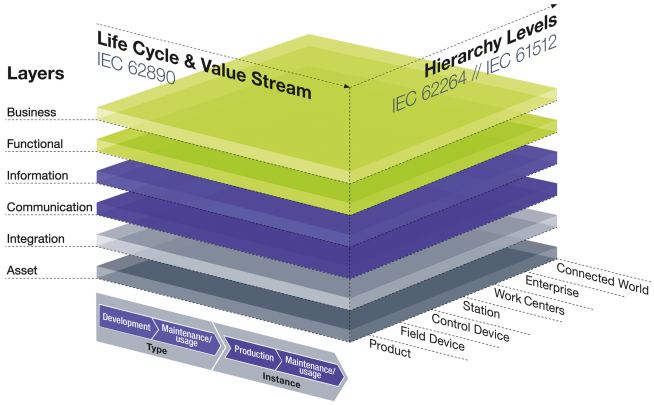
The difference between these initiatives does not lay in the goals but rather in the selection of enabling technical solutions (e.g. wireless or not, use of internet or proprietary networks, point-to-point communication or not, cloud-based or not, etc).

What terminology is used and what does it mean?

Industry 4.0 uses a set of key terms as explained below.

- Cyber Physical Systems;
  There is no exact definition of CPS. Common explanation stretches from more basic mechatronics to fully connected and simulated systems.
  A basic explanation states that CPS is a system composed of physical entities such mechanisms controlled or monitored by computer-based algorithms. According to this explanation, CPS is closely related to Embedded Systems, however in embedded systems the emphasis tends to be more on the computational elements, and less on an intense link between the computational and physical elements. Following to the same explanation, CPS can also be seen as related to Internet of Things (IoT), however, in IoT the fact that the computer-based algorithms are connected to internet is stressed.
  A more elaborated explanation states that, in addition to a physical entity controlled by computer-based algorithms, a CPS also has a digital twin. The digital twin of the real machine operates in the cloud platform and simulates the operations and conditions of the machine. The simulation is based on with an integrated knowledge from both data driven analytical algorithms as well as other available physical knowledge.

- Reference Architecture; The Reference Architectural Model Industrie 4.0, abbreviated RAMI4.0, consists of a three-dimensional coordinate system that describes all crucial aspects of Industrie 4.0. In this way, complex interrelations can be broken down into smaller and simpler clusters.



- Internet of Things and Services; The Internet of Things (IoT) is the network of physical objects (e.g. devices, vehicles, buildings and other items) embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data. The functionalities that these objects provides are refered to as services.

- Self-optimized value-chains; The concept implies that the process in the value-chains do not have to be repeated but can be optimized based on each individual product.

What research is needed?

Technical research is needed in the areas of:

- Embedded systems;
- Distributed systems;
- Networked systems;
- Wireless communication;
- Process management;

What are the greatest challenges?

The most important challenges for realizing Industry 4.0 have been identified through a survey as (most important challenge given first); standardization, work organization, product availability, new business models, security know-how protection, lack of specialist staff, research, training and Continuing Professional Development (CPD), regulatory framework.

The most important assistance for implementing Industrie 4.0 have been identified though a survey as are recognized as (most important challenge given first); sharing experiences, regular newsletter, involvement in working groups, training courses, involvement in research projects, and online forums.

Business Impact?

It is believed that industry 4.0 will have an impact on the business models used by manufacturing companies. Since the response times will drastically shorten, as an effect of the horizontal and vertical integration, new business models will emerge.

More info

Examples of useful documents if you want more information about Industry 4.0:

- Industrie 4.0 Working Group. 2013. “Recommendations for implementing the strategic initiative INDUSTRIE 4.0.” acatech
- Industrie 4.0: The Reference Architectural Model Industrie 4.0 (RAMI 4.0), ZVEI German Electrical and Electronic Manufacturers’ Association
- More …

Concluding remarks

This whitepaper aims at providing you with an introduction to Industry 4.0, a German initiative aiming at advancing the manufacturing industry. There are several similar initiatives aiming at advancing the industrial sector. They all foresee tighter integration in the four integration perspectives and they therefore share some common research issues and additional challenges. However, they also differ in some respects, mainly concerning technology requirements.

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