Smart Manufacturing/Industry 4.0 in Europe

INTRODUCTION

The Manufacturing industry is a strong asset of European economy, accounting for 22 million enterprises, 33 million jobs and is responsible for 15% of Gross Domestic Product (GDP). The sector is also responsible for 64% of private sector Research & Development expenditure and for 49% of innovation expenditure in Europe.

The terms “digital manufacturing” or “smart manufacturing” or “intelligent manufacturing” refer to communication and computing technologies which enable all players in the value chain of products at the supply chain, enterprise and shop floor levels to be digitally connected and data analytics-driven, thus achieving intelligent coordination for demand and supply matching, faster time to market, mass customisation and cost benefits. Engineers are developing Manufacturing Control Tower (MCT) for this purpose. Maintenance of machinery is an area of focus.

New digital and smart technologies are improving processes within the manufacturing industry, leading to what is being called the ‘fourth Industrial Revolution’ or ‘Industry 4.0’. Industry 4.0 or Manufacturing IoT systems connect the components of a production process in a factory. Their purpose is to enable “smart manufacturing”. In smart factories, cyber-physical systems monitor physical processes and make decentralised decisions. Via their IoT connection, these cyber-physical systems can communicate and cooperate with each other and with humans in real time. Connected devices include manufacturing equipment and robots.

Data will play a key role in the transformation of manufacturing, but it poses significant challenges in terms of security. Manufacturing facilities will need to be digitally connected with external partners in the value chain, so it is important to guarantee an adequate level of security without limiting the capability to exchange data and information both on the manufacturing floor and beyond the factory.

While factories will become more autonomous, manufacturing processes are designed and controlled by engineers, so a highly skilled workforce becomes a pre-condition for the success of these innovation processes. Energy sustainability will also be essential, reducing resource consumption and waste generation to make the sector ready for the low-carbon economy.

Europe is projected to account for more than a third of global Industry 4.0 investments by 2020. Western and northern Europe are its main markets; especially Germany, where the term was originally coined, is a frontrunner. The market is expected to grow at an impressive average annual growth rate of 22%. Reaching a value of €287 billion in 2020, Industry 4.0 is Europe’s largest IoT market. Both national and European initiatives are working to stimulate the rollout of Industry 4.0 and lower barriers

The main design principles of Industry 4.0 are the following:

- **Interoperability:** Cyber-physical systems allow humans and smart factories to connect and communicate with each other.
- **Virtualisation:** Linking sensor data from cyber-physical systems to virtual plant models and simulation models creates a virtual copy of the smart factory.

- **Decentralisation:** Cyber-physical systems make autonomous decisions and produce locally.
- **Real-time capability:** Data is collected, analysed and translated into insights immediately.
- **Service orientation:** All services of cyber-physical systems and humans are available internally or even cross-company.
- **Modularity:** Smart factories are flexible and can adapt to changing requirements by replacing or expanding individual modules.

Implementing Industry 4.0 systems can generate considerable benefits for European companies by monitoring operations, providing insights and suggesting methods of improvement. This allows companies to improve operational efficiency and machine uptime, while lowering maintenance cost. In fact, companies that use Industry 4.0 technology can perform 10 times better than their peers by being 10 times more effective, efficient and/or faster. They use, for example, smart devices, connected objects and sensors, cloud and big data analytics. However, more than 41% of European small and medium-sized enterprises (SMEs) do not use these techniques yet. This is an opportunity for Industry 4.0 service providers.

POLICY INITIATIVES

An EU-funded project is developing proposals to feed into a smarter manufacturing strategy for Europe. Taking into consideration new digital technologies and smart specialisation initiatives, the project's proposals will inform policymakers on the best ways to boost Europe's competitiveness for growth and jobs. EU-funded project MAKERS brings together a range of European and international organisations to study issues affecting competitiveness, such as novel technologies, globalisation, regional smart specialisation, the role of small companies, local value chains, skills development and sustainability, among others. MAKERS received funding through the EU's Marie Skłodowska-Curie actions programme and organised annual summer schools for young researchers covering a range of issues involved in developing proposals and examining methodologies.

The EU's research & innovation (R&I) programmes have steadily supported the development of technologies and solutions that enable the European manufacturing sector to take full advantage of digital opportunities. Many projects are financed by the Factories of the Future Public-Private Partnership, and they cover areas such as digital automation, process optimisation of manufacturing assets, simulation and analytics technologies and ICT innovation for manufacturing SMEs.

Currently, the European R&I programme Horizon 2020 has the following open calls related to connected smart factories:

- ICT-08-2019 – Security and resilience for collaborative manufacturing environments
- DT-ICT-07-2018-2019 – Digital Manufacturing platforms for connected smart factories
- DT-ICT-13-2019 – Digital Platforms/Pilots Horizontal activities
- DT-ICT-03-2020 – I4MS phase 4- uptake of digital game changers and digital manufacturing platforms (planned for 2020)
- ICT-38-2020 – Artificial intelligence for manufacturing (planned for 2020)
- ICT-39-2020 – Digital advances for local/urban manufacturing (planned for 2020)

Several European countries have launched or are launching national initiatives to stimulate Industry 4.0 implementation. These initiatives include the following:

Industrie 4.0 (Germany)

Industrie 4.0, the 4th industrial revolution, is enabled by a networked economy and powered by smart devices, technologies and processes that are seamlessly connected. The vision for the 4th industrial revolution is for cyber-physical production systems which provide digital representation, intelligent services and interoperable interfaces in order to support flexible and networked production environments. Smart embedded devices will begin to work together seamlessly, for example via the IoT, and centralized factory control systems will give way to decentralized intelligence, as machine-to-machine communication hits the shop floor.

The Industrie 4.0 vision is not limited to automation of a single production facility. It incorporates integration across core functions, from production, material sourcing, supply chain and warehousing all the way to sale of the final product. This high level of integration and visibility across business processes, connected with new technologies will enable greater operational efficiency, responsive manufacturing, and improved product design.

While smart devices can in many ways optimize manufacturing, they conversely make manufacturing far more complex. The level of complexity this creates is immense, because it not only concerns isolated smart devices, but involves the whole manufacturing environment, including various other smart devices, machines and IT systems, which are interacting across organizational boundaries.

Industrie 4.0 and its underlying technologies will not only automate and optimize the existing business processes of companies; it will also open new opportunities and transform the way companies interact with customers, suppliers, employees and governments. Examples of this are emerging business models based on usage and metering.

To push forward Industrie 4.0 applications, there exists a broad community encompassing industrial associations in Germany such as VDMA, Bitkom, and ZVEI, large companies and research organizations. Driven by this community, governmental initiatives such as national or regional studies and research programmes have been launched, in addition to the efforts being undertaken by industrial companies.

http://www.plattform-i40.de/I40/Navigation/EN/Home/home.html

New Industrial France (France)

The “New Industrial France” or NFI in French- “Nouvelle France Industrielle” was launched in April 2015 to succeed the reindustrialization of France. The New Industrial France programme is based on 9 industrial solutions that provide real-world responses to key economic and social challenges. These solutions will position French businesses on tomorrow’s markets in a world in which digital technology is erasing the boundary between industry and services. Large-scale means have been put in place to support ambitious industrial projects and step up the deployment of the goods and services of tomorrow.

a. Data economy
b. Smart objects
c. Digital trust
d. Smart food production
e. New resources
f. Sustainable cities
g. Eco-mobility
h. Medicine of the future
i. Transport of tomorrow

https://www.economie.gouv.fr/files/files/PDF/web-dp-indus-ang.pdf

In October 2017, the "French Fab" brand was launched to represent the French ecosystem of industry in France and abroad. Whatever the size of the companies, from medium size companies to international groups, all of them focus on local expertise, factories, and engineering offices and are open to great evolutions based on digital, new technologies or green economy. All of them have a long-term project and are involved either in manufacturing or providing services, to build the Industry of the future "à la Française".

https://www.lafrenchfab.fr/#Partenaires will provide you with the list of the French FAB partners.

http://www.economie.gouv.fr/vous-orienter/entreprise/industrie/nouvelle-france-industrielle

Smart Industry (Netherlands)

The Smart Industry (SI) initiative was launched in November 2014 by the government and industry stakeholders. The objectives are to strengthen the Dutch manufacturing industry position and increase industrial productivity. Smart Industry is structured around three main action lines that seek to capitalize on existing knowledge, accelerate and introduce ICT in companies and strengthen knowledge, skills and ICT conditions.

- The first action line concerns the use of existing knowledge and focuses on the gathering and dissemination of knowledge to businesses. This is carried out by providing companies with technological and market understanding, best practices and tools. Specific activities cover presentations, a website, online training modules and business team trainings.
- The second action line, acceleration through field labs, is assumingly the most visible part of SI. It seeks to create national and regional ecosystems and interrelated networks of companies and knowledge institutions with a basis in SI principles. The field labs present practical environments for design, testing, experimentation and deployment of technology solutions. The labs work as operational environments where people can join for discussion, meetings etc. It is basically a location with a programme that is made up of multiple try-out innovation projects and planned training within projects.
- The third action line is of a more long-term nature and aims to improve knowledge, skills and ICT conditions. In terms of knowledge, it is focused on strengthening R&D incentives in field labs and to develop a long-term SI research agenda together with top sectors and universities. Human capital conditions are sought upgraded through adapting relevant educational courses and

programmes – ranging from primary education to scientific education and dual education - to the needs of SI. It seeks to offer modular educational blocks and to organise courses on sustainable production. ICT conditions are targeted by a vision to develop an increasingly solid and secure ICT infrastructure and by a research programme for the development of software tools that cover chain collaboration, interoperability and standardization.

https://ec.europa.eu/growth/tools-databases/dem/monitor/content/netherlands-smart-industry

Others:

- Italy – Intelligent Factories ,
- Spain: Industria Conectada 4.0
- Slovakia – Smart Industry
- Austria: Plattform Industrie 4.0
- Poland: "Initiative for Polish Industry 4.0 – The Future Industry Platform"
- Portugal "Indústria 4.O"
- Lithuania: "Pramonė 4.0"
- Hungary: "IPAR 4.0 National Technology Platform"

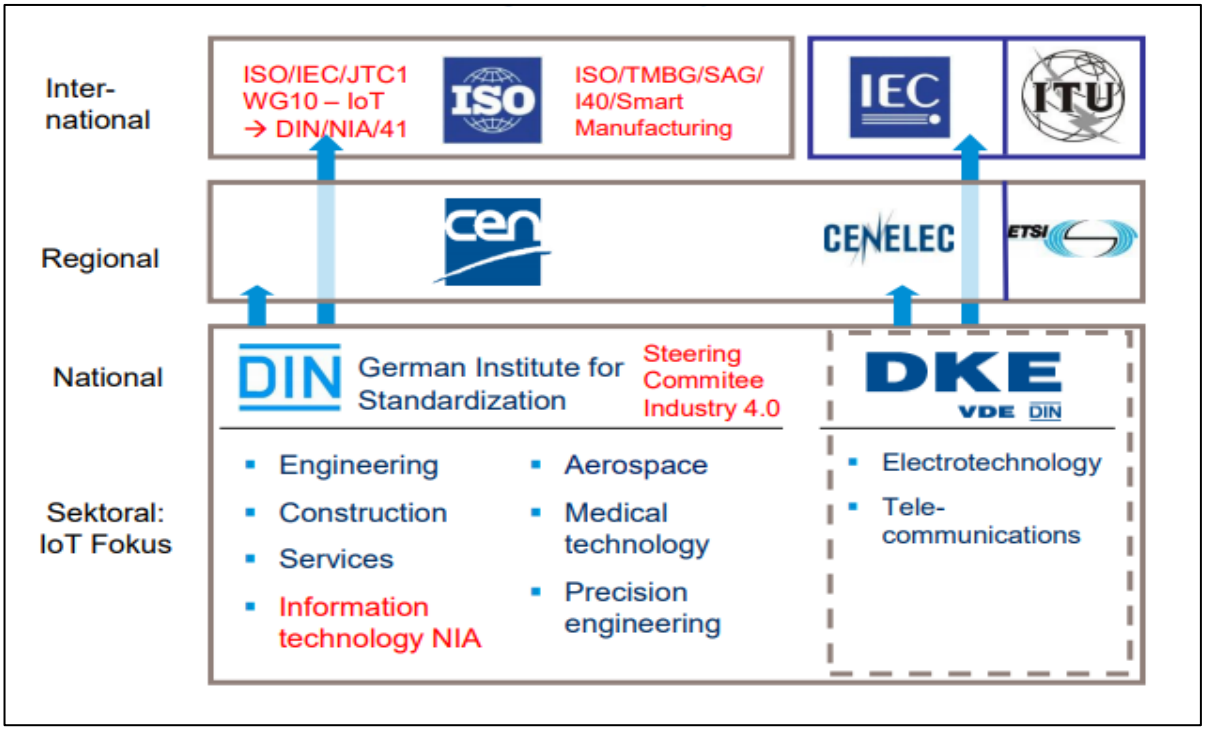
National initiatives like these can have a positive effect on the market for Industry 4.0 services in these countries. They often invite companies to participate and give input on important subjects to make the transition easier. They do so, for example, via workshops with stakeholders, including scientists, associations, trade unions and federal ministries.

STANDARDIZATION

For a successful implementation of Industry 4.0 across Europe, standardisation is crucial. To allow devices/equipment to communicate regardless of manufacturer, operating system or other technological details, there should be standards for systems, platforms, protocols, connections and interfaces.

Currently, these standards are lacking. This is a considerable barrier for companies. In fact, for 21% the need for standardisation is the main challenge keeping them from implementing Industry 4.0 systems. The European Commission is now working on the development of European standards.

The development of standards and specifications takes place on a variety of levels (national, European and international). A suitable overview, showing the way in which the development of standards and specifications is organized on a national, European and international level can be found in the illustration above, which depicts the standards organizations and their interaction.



***Note:** DIN and DKE represent German interests in European and international standardization.*

In Germany, DIN and DKE are the main bodies involved; in Europe CEN, CENELEC and ETSI are involved; and ISO and IEC act on an international level. In addition to these officially mandated bodies, other groups are drawing up standards and guidelines for standardizing Industry 4.0.

The international standards organizations ISO and IEC have recognized that it is not enough for work on the complex topic of Industrie 4.0 to be left to single technical committees (TC) working in isolation. For that reason, a strategic body was set up **(ISO Smart Manufacturing Coordinating Committee (ISO/SMCC) and IEC System Committee Smart Manufacturing (IEC/SyC)),** which consists of representatives from all relevant TCs and which coordinates the standardization work throughout the organizations.

In Europe, the standardization work is being driven forward by various technical committees of CEN/CENELEC: these are,

- **CEN/TC 438 - Additive Manufacturing:** Standardization in the field of Additive Manufacturing (AM): The main objective of the committee is to standardize the processes of Additive Manufacturing, the test procedures, environmental issues, quality parameters and vocabularies.
  The new technical committee will have three main goals:
  - To provide a complete set of European standards, part of which will be developed based on the international standardization work of ISO;
  - To strengthen the link between European research programs and standardization in AM;
  - To ensure transparency and visibility of the European standardization in AM.

  For more information please click here

- **CEN/TC 310 - Advanced automation technologies and their applications:** Standardization in the field of automation systems and technologies and their application and integration to ensure the

availability of the standards required by industry for design, sourcing, manufacturing and delivery, support, maintenance and disposal of products and their associated services.

For more information about structure, work program and published standards please click here

- **CLC/TC 65X: Industrial-Process measurement, control and automation**
  To contribute, support and coordinate the preparation of international standards for systems and elements used for industrial process measurement, control and automation at CENELEC level. To coordinate standardisation activities which affect integration of components and functions into such systems including safety and security aspects. This CENELEC work of standardisation is to be carried out for equipment and systems and closely coordinated with IEC TC65 and its subcommittees with the objective of avoiding any duplication of work while honouring standing agreements between CENELEC and IEC.

  For more information please click here

Nowadays, almost 90% of standardization work is geared towards the European and international levels, with DIN and DKE organizing the entire process of standardization on the national level and ensuring German involvement in the European and international processes through the corresponding national committees (see Table below):

Industrie 4.0: Relevant committees and consortia	
National committees and consortia	**Standards and specifications**
DIN/DKE	DIN SPEC 27070 Reference architecture of a security gateway for the exchange of industry data and services DIN SPEC 16593-1 RM-SA – Reference Model for Industrie 4.0 Service architectures – Basic concepts of an interactionbased architecture DIN SPEC 91345 Reference Architecture Model Industrie 4.0 (RAMI4.0) DIN SPEC 16592 Combining OPC Unified Architecture and Automation Markup Language
VDI/VDE GMA	VDI/VDE 3682 Formalized process description VDI/VDE 3695 Engineering of facilities VDI 4499 Digital Factory VDI 5600 MES
CEN/CLC	EN Standards
ETSI	EN-Standards SDR|VNF/Radio/ 4G, 5G/Security/M2

DIN and DKE founded the Standardization Council Industrie 4.0 (SCI 4.0) 4 in conjunction with the industry associations BITKOM, VDMA and ZVEI. SCI 4.0 is responsible for orchestrating standardization activities and, in this role, acts as a point of contact for all matters relating to standardization in the context of Industrie 4.0. In collaboration with the Plattform Industrie 4.0, SCI 4.0 brings together the interested parties in Germany and represents their interests in international bodies and consortia. SCI 4.0 also supports the concept of practical testing in test centres by initiating and implementing new informal standardization projects tailored to meet specific needs.

Working Groups at DIN

Industrie 4.0 topics are handled by various committees at DIN. These include, among others:

- IT Security Coordination Office (KITS)
- DIN Standards Committee Services (NADL)
- DIN Standards Committee Mechanical Engineering (NAM)
- DIN Standards Committee technology of materials (NWT)
- DIN Standards Committee Machine Tools (NWM)
- DIN Standards Committee Tools and Clamping Devices (FWS)
- DIN Standards Committee Safety Design Principles (NASG)
- DIN Standards Committee Information Technology and selected IT Applications (NIA)
- DIN Standards Committee Ergonomics (NAErg)
- DIN Standards Committee Technical Fundamentals (NATG)

The work results from these committees all flow into the SCI 4.0.

The table below summarized published standards relevant for smart manufacturing:

List of Standards relevant for Smart Manufacturing	
Document No.	**Title**
DIN EN ISO 6385	Ergonomic principles in the design of work systems
DIN EN ISO 9001	Quality management systems -- Requirements
DIN ISO 45001	Occupational health and safety management systems - Requirements with guidance for use
DIN EN 16710-2	Ergonomics methods - Part 2: A methodology for work analysis to support design
DIN EN 614-2	Safety of machinery - Ergonomic design principles - Part 2: Interactions between the design of machinery and work tasks
DIN ISO/TS 15066	Robots and robotic devices - Collaborative robots
DIN EN ISO 10218	Robots and robotic devices - Safety requirements for industrial robots
DIN EN 894-1	Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 1: General principles for human interactions with displays and control actuators

DIN EN ISO 12464	Light and lighting - Lighting of work places
DIN EN ISO 9241-960	Ergonomics of human-system interaction - Part 960: Framework and guidance for gesture interactions (ISO 9241-960:2017)
DIN EN ISO 9241-125	Ergonomics of human-system interaction - Part 125: Guidance on visual presentation of information (ISO/DIS 9241-125:2016)
DIN EN 1005-1-5	Safety of machinery - Human physical performance -Part 1-5
DIN EN 614-1-2	Safety of machinery - Ergonomic design principles - Part 1-2
DIN EN 894-1-4	Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 1- 4
DIN EN ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
DIN EN ISO 13857	Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs
DIN EN 13861	Safety of machinery - Guidance for the application of ergonomics standards in the design of machinery
DIN EN ISO 26800	Ergonomics - General approach, principles and concepts
DIN EN ISO 14738	Safety of machinery - Anthropometric requirements for the design of workstations at machinery
DIN EN 349	Safety of machinery - Minimum gaps to avoid crushing of parts of the human body
DIN EN 547-1	Safety of machinery - Human body measurements - Part 1: Principles for determining the dimensions required for openings for whole body access into machinery
DIN EN ISO 15265	Ergonomics of the thermal environment - Risk assessment strategy for the prevention of stress or discomfort in thermal working conditions
DIN EN ISO 7730	Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria
DIN CWA 16649	Managing emerging technology-related risks

These standards should make it easier for companies to connect their existing and new equipment, regardless of their service provider. Therefore, the publication of European standards is expected to drive the further rollout of Industry 4.0 in the coming years. Although such standards are voluntary, you should comply because they allow you to sell your products across Europe. A collection of standards relevant for smart manufacturing (Industry 4.0) can be downloaded from here

Some other international bodies active in Industry 4.0 standardization by the relevant committees given below:

1. Additive manufacturing (ISO/TC 261)
2. A) Cloud computing (ISO/IEC JTC 1 SC38), B) Information security (ISO/IEC JTC 1 SC27), C) Open electronic data interchange (ISO/IEC JTC1/SC30)
3. Industrial automation (ISO/TC 184)
4. Industrial measurement, control and automation (IEC/TC 65)
5. Information technology ISO/IEC JTC 1
6. ISO/IEC JTC 1/SC 42 Artificial Intelligence
7. ISO/TC 307 Blockchain and distributed ledger technologies
8. Systems aspects for electrical energy supply (IEC TC 8)
9. Robotics (ISO/TC 299): in development stage
10. Big Data (ISO/IEC JTC 1 WG9): in development stage
11. Internet of Things (ISO/IEC JTC 1 WG10): in development stage
12. Blockchain technology: in development stage

ABBREVIATIONS

Acronym	Expansion
AM	Additive Manufacturing
CEN	European Committee for Standardization
CENELEC	European Committee for Electro-technical Standardization
DIN	German Institute for Standardization
DKE	German Commission for Electrical, Electronics & Information Technologies of DIN and VDE
ETSI	European Telecommunications Standards Institute
EU	European Union
ICT	Information and Communication Technology
IEC	International Electro-technical Commission
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunication Union
MCT	Manufacturing Control Tower
R&I	Research & Innovation
SMCC	Smart Manufacturing Coordinating Committee
SMEs	Small and Medium Enterprises
SyC	System Committee
TC	Technical Committee

REFERENCES:

Industry 4.0 Europe: CBI

https://www.cbi.eu/node/2666/pdf/

European Commission: Digital Transformation Monitor

https://ec.europa.eu/growth/tools-databases/dem/monitor/category/national-initiatives

GERMAN STANDARDIZATION ROADMAP

https://www.din.de/blob/65354/57218767bd6da1927b181b9f2a0d5b39/roadmap-i4-0-e-data.pdf

DIN (German Institute for standardization)

https://www.din.de/en/innovation-and-research/industry-4-0/standards

DKE (German Committee for Electrical, Electronics & Information Technologies of DIN and VDE)

CEN (European Commission for Standardization)

https://www.cen.eu/Pages/default.aspx

CENELEC (European Committee for Electro-technical Standardization)

https://www.cenelec.eu/

Digitising European Industry

https://ec.europa.eu/digital-single-market/en/policies/digitising-european-industry

European Parliament: Industry 4.0 Digitalisation forproductivity and growth

http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf