Smart Manufacturing/Industry 4.0 in Europe

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1. INTRODUCTION

The Manufacturing is the backbone of the European economy and is responsible for 15% of Gross Domestic Product (GDP). The sector accounts for:

- 28.5 million people employed in almost 2 million enterprises, out of which 99.2% are SMEs.
- the EU27 has 22% of the world's manufacturing output, yielding a trade surplus in manufactured goods of €421 billion annually.

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.

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.

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.
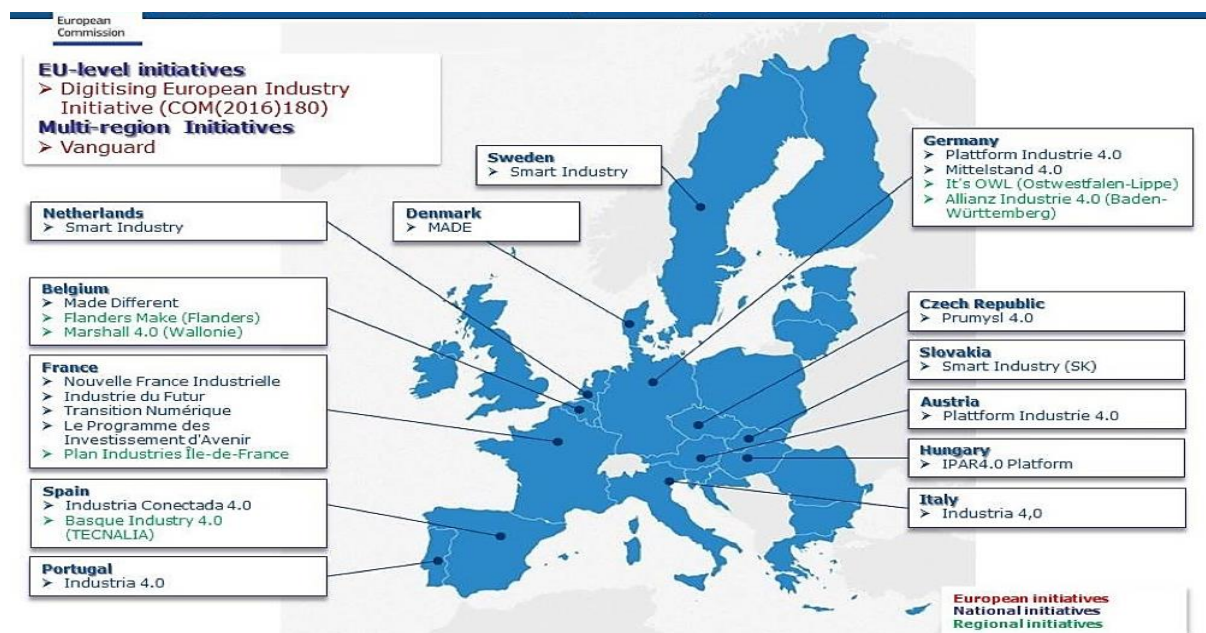
- **Modularity:** Smart factories are flexible and can adapt to changing requirements by replacing or expanding individual modules.

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.

European Industry 4.0 market was valued at $24.5 billion in 2020 and will grow by 16.4% annually over 2020-2030 owing to the improved operational efficiency and productivity, rising R&D investment, and significant technological advancements in IoT, 3D printing industry, Artificial Intelligence (AI), big data, 5G network, extended reality including AR & VR, and machine learning[1].

2. POLICY INITIATIVES

There are a number of initiatives around Smart manufacturing/industry 4.0 in Europe and in the Member States. The objective at the European level is to strengthen the coordination among the various initiatives and to facilitate the deployment of smart manufacturing at a pan-European level, thus improving the competitiveness of the European manufacturing industry both in the Single Market and on a global scale and creating the conditions for the European technology providers to flourish.

2.1. DIGITISING EUROPEAN INDUSTRY INITIATIVE (DEI)

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[1] https://www.researchandmarkets.com/reports/5505902/europe-industry-4-0-market-2020-2030-by

In April 2016, the European Commission presented the Digitising European Industry initiative (DEI) as part of the [Digital Single Market (DSM) strategy](#) which aims to reinforce EU's competitiveness in digital technologies and to ensure that every business in Europe - whichever the sector, wherever located, whatever the size - can fully benefit from digital innovation.

The five pillars of the Digitising European Industry initiative are:
- **European platform** of national initiatives on digitising industry to coordinate and ensure coherence among Member States digitising industry initiatives.
- **Digital innovations for all**: Digital Innovation Hubs
- **Strengthening leadership through partnerships and industrial platforms** to support the development of digital industrial platforms and large-scale piloting and Public-Private Partnerships (PPPs) in key digital technologies such as 5G, big data, High Performance Computing, cybersecurity, photonics, robotics and electronic components & systems.
- **A regulatory framework** fit for the digital age to regulate and provides digital-friendly regulatory framework in the European Union.
- **Preparing Europeans for the digital future** to adapt the education and learning systems to the digital transformation as well as reskilling Europeans.

For more information, please [click here>>](#)

2.2. EU INDUSTRIAL STRATEGY

On 10 March 2020, the European Commission launched a New Industrial Strategy for Europe, highlighting its overarching ambitions for the 'twin transition', a journey towards climate neutrality and digital transformation. The EU Industrial Strategy outlines three drivers for industrial transformation: global competition, climate neutrality, and a digital future.

The strategy is underpinned by a set of inter-connected and reinforcing elements: (1) certainty for industry and a deeper and more digital single market, (2) upholding a global level playing field, (3) a shift to climate neutrality, (4) building a more circular economy, (5) embedding industrial innovation, (6) skilling and re-skilling, and (7) investment and financing the transition. Due to the COVID-19 crisis, the EU Industrial Strategy was updated to promote Europe's recovery in May 2021. For more information, please [click here>>](#)

2.3. HORIZON EUROPE

Horizon Europe is the research and innovation support programme in a system of European and national funding programmes that share policy objectives. Under the pillar II of Horizon Europe, [Cluster 4](#) focuses on digital, industry and space and aims to deliver six 'destinations' matching the strategic plan (e.g. digital and emerging technologies for competitiveness and fit for the Green Deal; a human-centred and ethical development of digital and industrial technologies, etc.). The main area of interventions for this Cluster are among others:

- artificial intelligence and robotics
- advanced computing and Big Data
- emerging enabling technologies and
- space including earth observation.

[EN Horizon Europe Work Programme 2023-2024: 7. Digital, Industry and Space](#)

2.4. HORIZON EUROPEAN PARTNERSHIP MADE IN EUROPE (MIE)[2]

Made in Europe is a Horizon Europe co-programmed public-private partnership running for 7 years with a budget of €1.8 billion in total. The European Factories of the Future Research Association (EFFRA) represents the private side in the partnership. Made in Europe is successor to the Factories of the Future Partnership which has been run under the Horizon 2020 programme.

Made in Europe seeks to increase the number and attractiveness of jobs in manufacturing, while securing the environmental, economic and social sustainability for future generations in Europe.

The partnership will contribute to a competitive, green, digital, resilient and human-centric manufacturing industry in Europe. It will be at the centre of a twin ecological and digital transition, being both a driver and subject to these changes. The 2030 vision for the partnership is to reinforce the global position Europe's manufacturing industry in terms of competitiveness, productivity, and technology leadership.

2.5. VANGUARD INITIATIVE

The Vanguard Initiative is a unique alliance that gathers 39 of the most advanced industrial regions in Europe, focused on stimulating industrial innovation and building European value-chains based on complementarities in regional smart specialisation strategies.

By connecting innovation ecosystems and sharing knowledge and facilities across its member regions, the Vanguard Initiative facilitates interregional collaboration, stimulates interregional innovation investments, strengthens open innovation, and speeds up the introduction and market-uptake of new products and innovations in Europe. Read more>>

2.6. NATIONAL INITIATIVES

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

2.6.1. INDUSTRIE 4.0 (GERMANY)

Germany has established itself as the world's Industrie 4.0 hotspot, with "Industrie 4.0" likewise being firmly positioned as a strong international brand. "Industrie 4.0" (Industry 4.0 (I40)) is a national strategic initiative from the German government through the Ministry of Education and Research (BMBF) and the Ministry for Economic Affairs and Energy (BMWI). It aims to drive digital manufacturing forward by increasing digitisation and the interconnection of products, value chains and business models. It also aims to support research, the networking of industry partners and standardisation.

I40 is pursued over a 10-15-year period and is based on the German government's High Tech 2020 Strategy. The initiative was launched in 2011 by the Communication Promoters Group of the Industry Science Research Alliance (FU) that was convened and organised by BMBF and adopted through the

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[2] https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies/advanced-manufacturing_en

High-Tech Strategy 2020 Action Plan. I40 has become institutionalised with the Platform Industrie 4.0 (Platform I40) that now serves as a central point of contact for policy-makers. For more information please click here>>

2.6.2. INDUSTRY OF THE FUTURE (FRANCE)

The Industry of the Future (IdF) programme was launched by the French government in April 2015. It aims to support companies to deploy digital technologies, to transform companies and business models as well as to modernise production practices. IdF targets selected priority markets and comprises five pillars, respectively cutting-edge technologies, business transformation, training, international cooperation and promotion of IdF.

The programme is backed by the government and make up the second phase of the French strategy "La Nouvelle France Industrielle" (New Industrial France (NFI)), which was launched by the government in September 2013. IdF has launched the platform "Industry of the Future Alliance (IdFA)" in order to secure coordination and dialogue and to bring together industry and digital technology stakeholders from public and private sectors. IdF has offered a more focused and needs-oriented mechanism compared to its NFI predecessor. While it draws on government support, the involvement of industry, technology and research stakeholders as well as trade unions has been key in finding a common ground and in launching a network structure to

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.

For more information, please click here>>

2.6.3. 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.

For more information, please click here>>

2.6.4.   OTHER NATIONAL INITIATIVES

- Italy – Intelligent Factories, Industria 4.0
- 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"
- Czech Republic: "Průmysl 4.0"

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.

3.   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.

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 below, which depicts the standards organizations and their interaction.

In Europe CEN, CENELEC and ETSI are the main bodies involved; in Germany, DIN and DKE 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.

- **ISO Smart Manufacturing Coordinating Committee (ISO/SMCC):** The Smart Manufacturing Coordinating Committee (SMCC) is made up of the chairs of more than 20 identified Technical Committees (TCs) and subcommittees (SCs). Their mandate is threefold:
  - ✓ to coordinate across ISO committees,
  - ✓ to coordinate with other organizations, and
  - ✓ to advise the ISO Technical Management Board (TMB).

- **ISO/TC 184: Automation systems and integration:** ISO/TC 184 deals with industrial automation technologies, including automated manufacturing equipment, control systems and the supporting information systems, communications and physical interfaces required to integrate them in the world of e-business. **For the complete list of standards published by ISO/TC 184 is available [here>>](#)**

- **ISO/TC 261: Additive manufacturing:** ISO/TC 261 is responsible for Standardization in the field of Additive Manufacturing (AM) concerning their processes, terms and definitions, process chains (Hard- and Software), test procedures, quality parameters, supply agreements and all kind of fundamentals. For more information please [click here>>](#)

- **IEC System Committee Smart Manufacturing (IEC/SyC):** To provide coordination and advice in the domain of Smart Manufacturing to harmonize and advance Smart Manufacturing activities in the IEC, other SDOs and Consortia according to clause 2 in AC/22/2017 superseded by the AC/17/2018. For more information please [click here>>](#)

- **IEC/TC 65 is Industrial-process measurement, control and automation:** To prepare international standards for systems and elements used for industrial process measurement, control and automation. To coordinate standardization activities which affect integration of components and functions into such systems including safety and security aspects. This work of standardization is to be carried out in the international fields for equipment and systems. For more information please [click here>>](#)

- **Joint ISO/TC 184 - IEC/TC 65/JWG 21 - Smart Manufacturing Reference Model(s):** ISO/IEC JWG 21 is a joint committee established between ISO TC 184, Automation Systems and Integration, and IEC TC 65, Industrial-process measurement, control and automation, under direction of the IEC Standardization Management Board and the ISO Technical Management Board. The objective of JWG21 is to create a unifying reference model for smart manufacturing. The reference model will guide organizations in developing their own architecture models for deploying standards-based solutions for smart manufacturing. For more information, please [click here>>](#)

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

- ISO/TC 292: Security and resilience

- ISO/IEC JTC1/SC 31 Automatic identification and data capture techniques;
- ISO/IEC JTC1/SC 41 Internet of Things and related technologies;
- ISO/IEC JTC 1/SC 42 Artificial Intelligence
- ISO/IEC JTC 1: Information technology
- ISO/IEC JTC 1/SC 27: Information security, cybersecurity and privacy protection
- ISO/TC 299 Robotics
- ISO TC 229 Nanotechnology
- ISO/IEC JTC1/SC 38 Cloud Computing and Distributed Platforms
  ISO/TC 307 Blockchain and distributed ledger technologies
- IEC TC 8: Systems aspects for electrical energy supply
- IEC TC 3: Information structures and elements
- IEC/SC 3D: Products properties, classes and their identification

In Europe, the standardization work is being driven forward by various technical committees of CEN/CENELEC and ETSI: 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:
  o To provide a complete set of European standards, part of which will be developed based on the international standardization work of ISO;
  o To strengthen the link between European research programs and standardization in AM;
  o 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**

- **CEN-CLC-ETSI/SMa-CG Coordination Group on Smart Manufacturing:** The CEN-CENELEC-ETSI "Coordination Group on Smart Manufacturing" (SMa-CG) was founded in 2019 and is managed by DIN/DKE. The Coordination Group advises on current European activities related to Smart

Manufacturing and synchronizes the position of CEN, CENELEC and ETSI vis-à-vis SDOs and other third parties on standardization. For more information, please click here>>

Following technical committees at CEN are also responsible for the important standardization work in emerging technologies surrounding Industry 4.0.

CEN Committee	Titled
CEN/TC 114	Safety of Machinery
CEN/TC 122	Ergonomics
CEN/TC 143	Machine Tools Safety
CEN/TC 225	AIDC Technologies
CEN/TC 290	Dimensional and Geometrical Product Specification and Verification
CEN/TC 319	Maintenance
CEN/TC 352	Nanotechnologies
CEN/TC 368	Product Identification
CEN/CLC/JTC 13	Cybersecurity
CEN/CLC/JTC 14	Energy management and energy efficiency in the framework of energy transition
CEN/CLC/JTC 19	Blockchain and Distributed Ledger Technologies
CEN-CLC/JTC 21	Artificial Intelligence

European Telecommunications Standards Institute (ETSI), an European Standards Organization (ESO), is dealing with telecommunications, broadcasting and other electronic communications networks and services. ETSI through its Industrial Specification groups (ISG) as well as Technical Committees is carrying out important standardization work in emerging technologies.

- ETSI ISG on Securing Artificial Intelligence (SAI): ISG SAI focuses on three key areas: using AI to enhance security, mitigating against attacks that leverage AI, and securing AI itself from attack. The ETSI ISG SAI works alongside a landscape of huge growth in AI, creating standards to preserve and improve the security of Artificial Intelligence.
- ETSI TC CYBER: ETSI TC CYBER is responsible for developing standards that increase privacy and security for organizations and citizens across Europe and worldwide.
- ETSI TC on Smart Machine-to-Machine Communications (SmartM2M): to develop standards to enable M2M services and applications and certain aspects of the Internet of Things (IoT).
  - ETSI SmartM2M Technical Committee has released SAREF4INMA specification, ETSI TS 103 410-5, to solve the lack of interoperability between various types of production equipment that manufacture items in a factory. It also enables different organizations in the value chain to uniquely track back the manufacturer items for the corresponding production equipment, batches and material and retrieve the exact time of production. The zero defects manufacturing use case has been used to improve the manufacturing process flexibility in order to switch from one manufactured product to another in a timely manner, generating as little yield loss as possible.

- ETSI ISG on Augmented Reality Framework (ARF): It aims to synchronize efforts and identify key use cases and scenarios for developing an ARF with relevant components and interfaces. It will provide technical requirements for AR specifications in order to ensure interoperable implementations that will benefit both technology providers and end-users. The work of the ISG started with an analysis of the AR standards landscape, the analysis of use case requirements and obstacles, and the development of a framework architecture.
  - ETSI GR ARF 002 V1.1.1 (2019-07): Augmented Reality Framework (ARF) Industrial use cases for AR applications and services
- ETSI ISG on Cross Cutting Context Information Management (CIM): ISG CIM aims to enable interoperable software implementations for Context Information Management. It is about bridging the gap between abstract standards and concrete implementations, especially for use cases related to Smart Cities, but also to be extended later to Smart Agrifood and Smart Manufacturing.
- ETSI ISG on Permissioned Distributed Ledger (PDL): ISG PDL analyses and provides the foundations for the operation of permissioned distributed ledgers, with the ultimate purpose of creating an open ecosystem of industrial solutions to be deployed by different sectors, fostering the application of these technologies, and therefore contributing to consolidate the trust and dependability on information technologies supported by global, open telecommunications networks.
- ETSI ISG F5G is addressing the use of fibre for industrial application to connect with the highest bandwidth and most secure technology each equipment in industrial production.

Nowadays, most of the 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.

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. More information

4. 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
VDE	Association of German Engineers
ZVEI	Central Association of the Electrical and Electronics Industry
VDMA	German Engineering Federation
BITKOM	Federal Association for Information Technology, Telecommunications and New Media

5. REFERENCES

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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 for productivity and growth

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

Rolling plan for ICT standardization: Advanced Manufacturing

https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/advanced-manufacturing

Horizon Europe

https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

Industry 4.0: Policy Brief from the Policy Learning Platform on Research and innovation

https://www.interregeurope.eu/sites/default/files/inline/INDUSTRY_4.0_Policy_Brief.pdf

ISO SMCC: whitepaper on Smart Manufacturing

https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100459.pdf

NSAI: Advance Manufacturing- Sectoral Study of Standards in Manufacturing

https://www.nsai.ie/images/uploads/standards/Sectoral_Study_of_Standards_in_Manufacturing.pdf