NSAI

Advanced Manufacturing

Sectoral Study of Standards in Manufacturing

Contents

FOREWORD

This document is informative in nature and provides an overview of the Industry 4.0 from a standards perspective, following the structure of 15 areas of focus.

It starts with a summary on what the "fourth industrial revolution" is, followed by an overview of the manufacturing sector in Ireland in 2019 and information on Ireland's digital transformation. It highlights European Policies and National Strategies and their potential impact on the industry as well as enabling changes to the current landscape.

The report highlights the importance of standards by emphasizing on the links and benefits achievable through standards and innovation, that can positively affect standardization. It also mentions some of the current funding mechanism that are available to support this action. The German Standardization Roadmap is referred to for its overview of standards and specifications relevant to Industry 4.0 with some strategic recommendations to address gaps and normative inconsistencies.

The relationship between standards and regulations is then detailed, exploring also how standards can support organizations' objectives. Specific attention is given to the Machinery Directive, where a comprehensive view into the latest ICT and emerging technologies from the "Impact assessment study on the revision of Directive 2006/42/EC on machinery" is listed along with its current shortcomings. The future revision of the directive is then examined through the recommendations of the Machinery Working Group.

The current standards and standardization process is then comprehensively examined and eleven enabling technologies are listed. The current and future applications of these technologies are investigated and linked to standards committees. The key relationships between emerging technologies and standardization is addressed and links are provided to published standards and current standardization activities.

Finally, this document maps the standardization activities of the European standards setting organizations, the International Organization for Standardization, and the International Electrotechnical Commission with respect to NSAI's National Mirror Committees.

INTRODUCTION

What is Industry 4.0?

Industry 4.0 is a term applied to a group of rapid transformations in technologies around the globe in terms of design, manufacture, operation and service of manufacturing systems and products. The 4.0 designation signifies that this is the world's fourth industrial revolution, the successor to three earlier industrial revolutions that caused quantum leaps in productivity and changed the lives of people throughout the planet.

Industry 4.0 implies the adoption in the industrial sector of technologies that have emerged and diffused in recent years. It ranges from a variety of digital technologies such as 3D printing, the Internet of Things (IoT) and advanced robotics, to new materials such as bio or nano-based, to new processes such as data-driven production, cybersecurity, artificial intelligence (AI) and synthetic biology. Industry 4.0 does not only involve the adoption of new technologies but also the adoption of the right skills, know-how, and organizational forms to fully exploit those new technologies.

What will Industry 4.0 change?

Digitalized manufacturing will trigger a wide range of changes to manufacturing processes, outcomes and business models.

Smart factories allow increased flexibility in production. Automation of the production process, the transmission of data about a product as it passes through the manufacturing chain, and the use of configurable robots means that a variety of different items can be delivered in the same facility. This mass customization will allow the production of "small lots" (single unique items) due to the ability to rapidly configure machines to adapt to customer-supplied specifications and additive manufacturing. This flexibility encourages innovation, since prototypes or new products can be developed quickly without complicated re-tooling or the setup of new production lines.

The speed with which a product can be made will also improve. Digital designs and the virtual modelling of manufacturing process can reduce the time between the design of a product and its delivery. Data-driven supply chains can speed up the manufacturing process by an estimated 120% in terms of the time needed to deliver orders and by 70% in time to get products to market.

Standards

Standards are essential to ensure the exchange of data between machines, systems and software within a networked value chain, as a product moves into and through the 'smart factory' towards completion, as well as to allow robots to be integrated into a manufacturing process through simple 'plug-and-play' techniques. If data and communication protocols are proprietary or only recognized nationally, only the equipment of one company or group of companies will be compatible; competition and trade can be expected to suffer, and costs rise. On the other hand, independent, commonly agreed, international standard communication protocols, data formats and interfaces can ensure interoperability across diverse sectors and different countries, encourage the wide adoption of Industry 4.0 technologies, and ensure open markets worldwide for European manufacturers and products[1].

[1] https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI%282015%29568337_EN.pdf

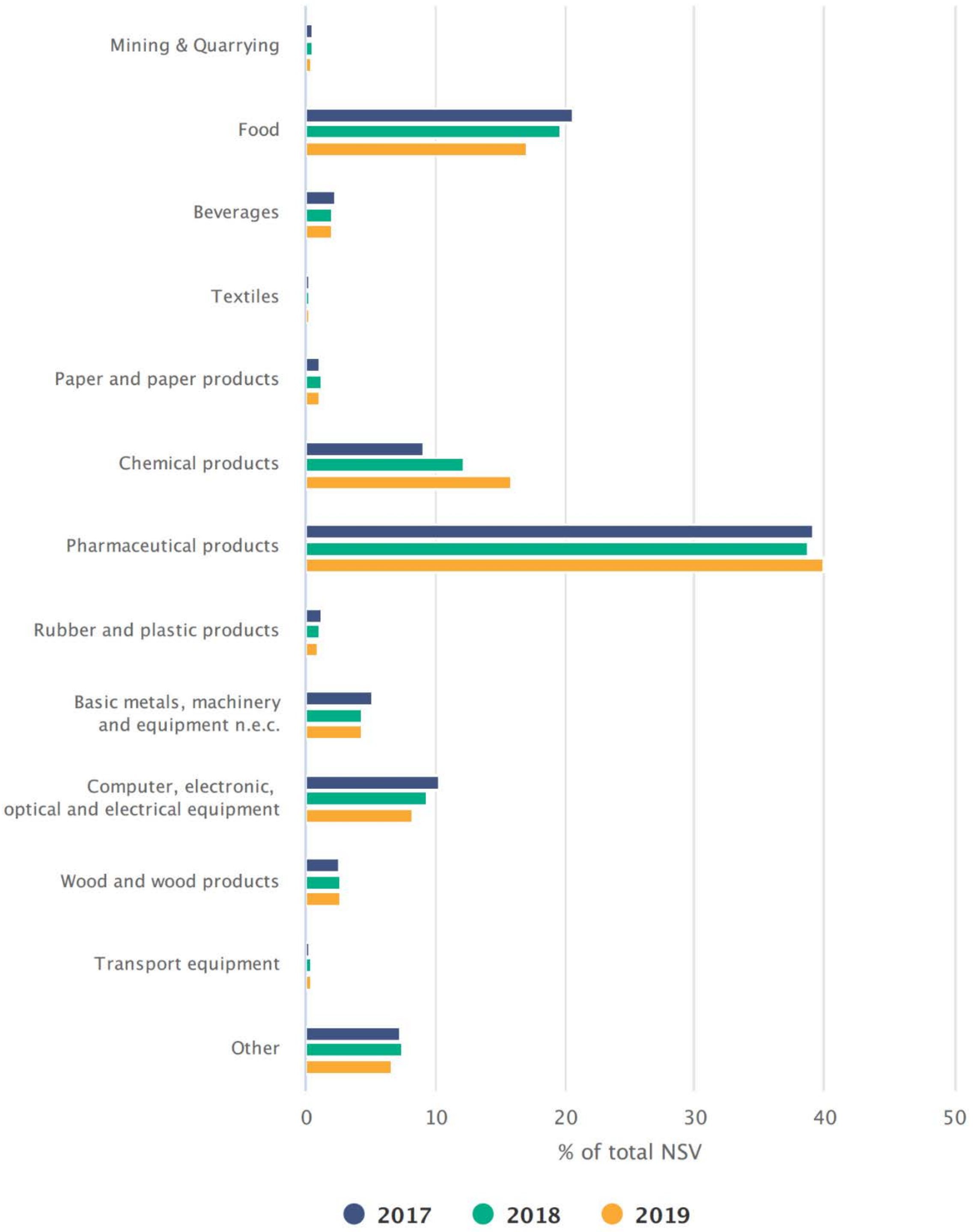

Figure 1: Composition of Net Selling Value by sector 2017-2019[2]

[2] https://www.cso.ie/en/releasesandpublications/er/iips/irishindustrialproductionbysector2019/

MANUFACTURING IN IRELAND

Manufacturing in 2019

According to the Central Statistics Office figures, in 2019 the industrial economy in Ireland contributed more than one third of Gross Value Added (GVA) 34.9% vs. the EU average of 19.7% while the previous year performance shows a continuation of 35.1% vs. EU average of 19.5%.

The top 10 industrial enterprises accounted for 51.7% of all production in Ireland in 2019. These industrial enterprises represented 75.4% of the overall Net Selling Value (NSV) with a value of €101.5 billion. This highlights that the Manufacturing sector in Ireland is heavily reliant on a very small number of enterprises.

Food, Chemical, Pharmaceutical products and the Computer sector, were the four largest sectors which accounted for 81.2% or €109.3 billion of total NSV in Ireland in 2019, up from 79.8% or €95.2 billion in 2018.

Top 10 industrial enterprises had in 2019 an aggregate NSV of €69.6 billion, while the remaining 3,654 industrial enterprises reported €65.0 billion. This data is based on the annual "PRODCOM" survey of industrial enterprises employing 3 or more people. These top 10 industrial enterprises contributed to over three quarters of the State's output delivering a total value of manufactured products in Ireland of €134.6 billion in 2019. This was an increase of 12.9% on 2018.

Food & Beverage Sector Trends 2017 to 2019

In 2019, the value of all Food and Beverages products was €25.8 billion and represented a lower percentage share of total NSV at 19.2%, compared to the previous two years. These sectors had a similar NSV of €26.0 billion in both 2018 and 2017, accounting for 21.8% of total NSV in 2018 and 22.9% of total NSV in 2017.

The Pharmaceutical Sector in 2019

Basic pharmaceutical products and preparations increased by 16.8% NSV from €46.1 billion in 2018 to €53.9 billion in 2019.

Growth Levels in the Irish Manufacturing Sectors since 2017

The Chemical sector recorded the largest percentage increase in NSV in Ireland between the years 2017 and 2019 with 107.0% growth recorded. Over the five-year period, 2015 (€16.7 billion) to 2019 (€21.4 billion), the growth rate in NSV for this sector was almost 28%, showing the volatility of NSV in the sector. From 2017 to 2019, transport equipment increased by 26.9% while the value of textiles, wearing apparel and related products rose by 25.7%. Between 2017 and 2019, the mining and quarrying sector experienced a decline in NSV of 6.4% while computer, electrical, optical and electrical equipment reported a fall of 5.2%.

Changes in Selected Manufacturing Products in 2019

The manufacture of cake and pastries grew by 24.6% from €256.3 million in 2018 to €319.3 million in 2019. Artificial joints rose from €832.4 million in 2017 to €1.2 billion in 2018 (46.8%) and increased again in 2019 by 17.1% to €1.4 billion. The annual manufacture of needles and catheters decreased from €2.6 billion in 2018 to €2.4 billion in 2019, a decrease of 10.2%.

In the Construction sector, the manufacture of ready-mixed concrete reported an 11.4% yearly increase in NSV terms, rising from €341.7 million in 2018 to €380.5 million in 2019. Building blocks and bricks had an NSV of €215.1 million in 2019, a 7.5% annual increase since 2018. This was lower than the annual increase of 25.2% from 2017 to 2018.

IRELAND'S DIGITAL TRANSFORMATION

Digital Economy and Society Index

The Digital Economy and Society Index (DESI) monitors Europe's overall digital performance and tracks the progress of EU 27 countries with respect to their digital competitiveness. This is a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU Member States in digital competitiveness. Countries are ranked on analysis of broadband connectivity, digital skills, use of the internet, digitisation of businesses, digital public services, emerging technologies, cyber security, the ICT sector, its R&D spending and Member States' use of Horizon 2020 funds.

The DESI was introduced in 2015 and measures the evolution as well as tracking the progress of the EU and of EU28 countries towards a more digitised economic system and society. Being a composite index, it comprises five key dimensions that, in their turn, summarise several indicators:

1. Connectivity;

2. Human Capital;

3. Use of Internet Services;

4. Integration of Digital Technology; and

5. Digital Public Services.

Ireland ranks 6th out of 28 EU Member States in the Digital Economy and Society Index (DESI) 2020. Over the last five years, Ireland was the fastest growing Member State in the EU.

Based on data prior to the pandemic, Ireland continued to rank first in the Integration of Digital Technology dimension and has maintained a leading position in the use of e-Commerce by SMEs. It entered the 'top 10' on the Use of Internet by individuals and recorded a notable increase in the share of internet users. It maintained its top 10 position in digital public services, where it excels in open data and the provision of digital public services for businesses. There was no substantial change in Ireland`s position in the Human Capital and Connectivity dimensions despite some improvement in key indicators where it has been lagging behind, such as the digital skills of the wider population[3].

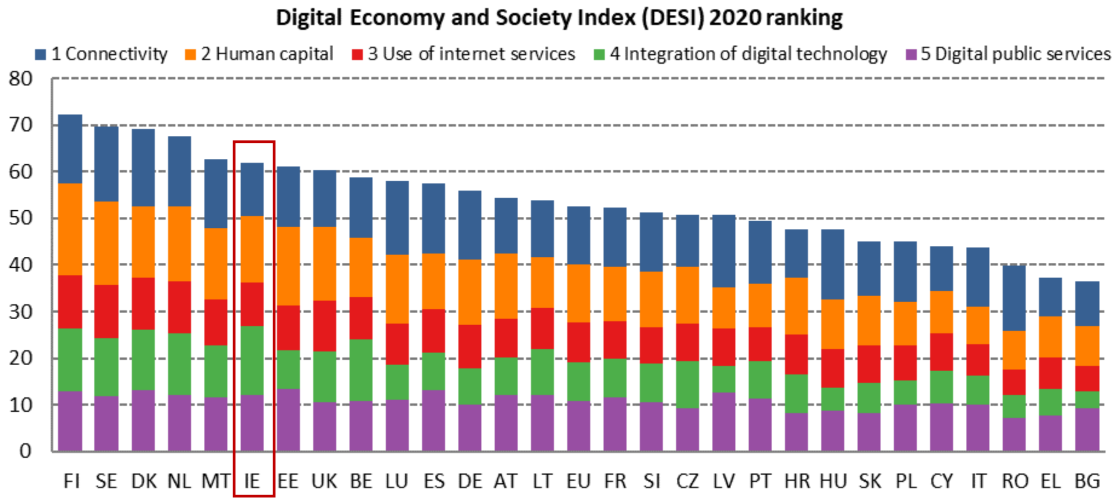

Figure 2: Digital Economy and Society Index (DESI) 2020 ranking[4]

[3] Department of Business, Enterprise and Innovation – Digital Single Market Bulletin Issue number 17, June 2020
[4] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi

Digital Transformation Monitor

The Digital Transformation Monitor (DTM) aims to foster the knowledge base on the state of play and evolution of digital transformation in Europe.

Ireland's overall performance in digital transformation is strong. Its highest scores are in the areas of supply and demand of digital skills and e-leadership. On the other hand, the areas of access to finance and the ICT start-up environment have room for improvement. Given its strong performance in e-leadership, it is not surprising that this field, together with the supply and demand of digital skills, is far above the EU average. Recent policy examples, such as the creation of the Digital Skills and Jobs Coalition and the implementation of entrepreneurship summer camps, confirm Ireland's strong performance in these fields.

The following strengths and areas for improvement were highlighted:

Strengths:

- Ireland's strong performance in the field of the supply and demand of digital skills is backed by the country's high innovation output; and
- A large workforce with tertiary education, as well as training provided to ICT employees by companies, which explains why e-leadership is Ireland's second-strongest pillar. This is supported by a high number of enterprises providing their employees with portable devices.

Areas of improvement:

- Ireland scores lowest in the field of ICT start-ups. Its relatively low performance in this dimension is mainly caused by a low birth rate of Irish ICT companies; and
- The area of investments and access to finance has moderate values. This performance can be explained by a low percentage of commercial profits of Irish companies. However, the average score in this field contrasts with the solid business R&D expenditure[5].

[5] https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Digital%20Transformation%20Scoreboard%202018_0.pdf

EUROPEAN POLICY PRIORITIES FOR INDUSTRY 4.0

Digital Single Market

In 2015, in the context of Europe 2020, the Commission launched (COM (2015) 192 final) its strategy to achieve a Digital Single Market (DSM), including improving industrial digitalisation in areas such as the data economy, Internet of Things(IoT), cloud computing, standards, skills and e-government. It aims to open digital opportunities for people and business and enhance Europe's position as a world leader in the digital economy[6].

Digitising European Industry

In April 2016, the Commission launched (COM (2016) 180 final) the "Digitising European Industry" (DEI) initiative as part of the DSM strategy, with encouragement from the Council. The DEI builds on and complements the various national and regional initiatives for the digitising industry that have been launched across Europe in recent years, and is structured around five main pillars:

- The European platform of national initiatives on Digitising Industry;
- Digital innovations for all - Digital Innovation Hubs;
- Strengthening leadership through partnerships and industrial platforms;
- A Regulatory Framework fit for the digital age; and
- Preparing Europeans for the digital future[7].

Europe is investing in digital: The Digital Europe Programme

As part of the next long-term EU budget which covers 2021 to 2027,– the Multiannual Financial Framework – the Commission has proposed Digital Europe, a programme focused on building the strategic digital capacities of the EU and on facilitating the wide deployment of digital technologies. With a planned overall budget of €8.2 billion, it will shape and support the digital transformation of Europe's society and economy.

Digital Europe will complement other EU programmes, such as the proposed Horizon Europe programme for research and innovation, as well as the Connecting Europe Facility for digital infrastructure[8].

The European Strategy for Data

The European strategy for data (COM (2020) 66 final) was published in February 2020 and aims at creating a single market for data that will ensure Europe's global competitiveness and data sovereignty. Common European data spaces will ensure that more data becomes available for use in the economy and society, while keeping companies and individuals who generate the data in control.

The European data space will give businesses in the EU the possibility to build on the scale of the Single market. Common European rules and efficient enforcement mechanisms should ensure that:

- Data can flow within the EU and across sectors;
- European rules and values, in particular personal data protection, consumer protection legislation and competition law, are fully respected; and
- The rules for access to and use of data are fair, practical and clear, and there are clear and trustworthy data governance mechanisms in place; Also, there is an open but assertive approach to international data flows, based on European values[9].

Shaping Europe's Digital future

Shaping Europe's digital future (COM (2020) 67 final) sets out a strategy for the next five years, where the Commission will focus on three key objectives to promote technological solutions that will help Europe pursue its own way towards a digital transformation that works for the benefit of people and respects our fundamental values:

- Technology that works for people;

[6] https://ec.europa.eu/digital-single-market/en/pillars-digitising-european-industry-initiative
[7] https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-180-EN-F1-1.PDF
[8] https://ec.europa.eu/digital-single-market/en/europe-investing-digital-digital-europe-programme
[9] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0066

- A fair and competitive economy; and
- An open, democratic and sustainable society.

The EU's digital strategy indicates the path that Europe needs to take to pursue its own way: a digital Europe that reflects the best of Europe.[10].

AI White Paper

AI permeates the Industry 4.0 ecosystem, it is the driving force for predictive maintenance on the factory floor, to the AI vision systems in the design stages and the European Commission recognizes its importance. On the 19th of February 2020 (COM(2020) 65 final), with the aim to promote the uptake of artificial intelligence (AI) while at the same time addressing the risks associated with its use, the European Commission has proposed a White Paper with policy and regulatory options "towards an ecosystem for excellence and trust". This document includes several references to support the use of standards to sustain the new regulatory framework and conformity assessment mechanisms required for the continuing and evolving inclusion of AI in Europe's digital transformation.

The White Paper sets out a rationale for prior conformity assessment for certain high-risk AI applications. The conformity assessments would include procedures for testing, inspection and calibration that already exist for other products placed on the market. The White Paper sees this conformity assessment being carried out by existing notified bodies. If this approach were to be pursued, it would be important to ensure that national accreditation bodies acquire the necessary expertise in order that they are able to audit AI systems in accordance with the relevant requirements identified.

In order to be able to demonstrate the trustworthiness of AI products and services and compete on a global scale, AI products could benefit from a certification scheme which would be based on the international and European standards currently being developed[11].

Ireland's National Submission to the EU White Paper on artificial intelligence can be found in the publication section of the Department of Enterprise Trade and Employment.

A New Industrial Strategy for Europe

On the 10th of March 2020 (COM (2020) 102 final) the Von Der Leyen Commission launched its new Industrial Strategy for a globally competitive, green and digital Europe marking the finish line of its first 100 days in office. As Europe is moving towards the goal of becoming the first climate-neutral continent in the world, industry is at the core of this transformation: all the industrial value chains will have to reduce their own carbon footprints and develop new business models.

To maintain the competitiveness of European businesses in their transition to become greener, more circular and digital, the new EU Industrial Strategy will focus on:

- Creating a more integrated and digital single market through the Single Market Enforcement Action Plan and an SME Strategy for a sustainable and digital Europe;
- Fostering competitiveness on the global stage with an Action Plan on the Customs Union and the White Paper on an instrument on foreign subsidies;
- Supporting industry towards climate neutrality with a set of initiatives including the EU Strategy on Clean Steel and Chemicals Strategy for Sustainability, the Carbon Border Adjustment Mechanism, EU Strategy on Clean Steel and the Chemicals Strategy for Sustainability;
- Promoting the reskilling and upskilling of the workforce through the launch of a European Pact for Skills; and
- Embedding circularity across the supply chain with the new Circular Economy Action Plan that focuses on sectors where this potential is high: electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction, and food[12].

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0067
[11] https://ec.europa.eu/digital-single-market/en/news/white-paper-artificial-intelligence-public-consultation-towards-european-approach-excellence
[12] https://www.csreurope.org/newsbundle-articles/the-eu-commission-unveils-new-european-industrial-strategy

IRELAND'S STRATEGIES

Ireland’s Industry 4.0 Strategy 2020-2025:2019

In December 2019 Ireland's industry 4.0 Strategy 2020-2025 was launched by the Department of Enterprise, Trade and Employment as an output from the Future Jobs Ireland 2019. This was published in response to the new digital technologies that have already begun to transform global manufacturing value chains, supply chains and business models, redefining sources of competitive advantage for both firms and national economies. For Ireland, with its strong manufacturing base, this presents both opportunities and challenges in key policy areas such as employment, productivity, competitiveness and sustainability. ‘Ireland’s Industry 4.0 Strategy’ sets out a vision to position Ireland at the forefront of this fourth industrial revolution thereby helping us to sustain our competitive manufacturing base. The aim is to deliver on the goals of the strategy by strategic actions under the following 6 themes:

Theme 1:	Future Manufacturing Ireland
Theme 2:	Awareness and Understanding of Concepts
Theme 3:	Exploring Planning
Theme 4:	Implementation of firm-level Industry 4.0 Strategies
Theme 5:	Framework Conditions
Theme 6:	Implementation of Ireland’s Industry 4.0 Strategy

Each of the six themes are expanded in the strategy setting out a series of numbered key actions under the responsibility of government departments.

The government has also established a new group, Future Manufacturing Ireland, to coordinate with government-funded research centres in this space and make it easier for companies to access expertise. A new Industry 4.0 stakeholder forum, with representatives from the manufacturing sector as well as Industry 4.0 experts, has also been convened to oversee implementation of the strategy[13].

National Digital Strategy:2013 (Under Review)

The first phase was launched by the Department of the Environment, Climate and Communications in 2013. This strategy focuses on digital engagement and how Ireland can benefit from a digitally engaged society. It sets out a clear vision and a number of practical actions to help increase the number of citizens and businesses engaging online through industry and enterprise, citizen training, schools and education.

A public consultation on a new National Digital Strategy was held at the end of 2018. This consultation invited members of the public and interested stakeholders to make submissions that would inform the scope and delivery of the new strategy which is now being drafted[14].

National Cyber security Strategy 2019

This Strategy was managed by a High-Level Steering Group, chaired by the Department of Communications, Climate Action and Environment. The main objectives are to ensure the state can respond to and manage incidents, including those with a national security component, and to protect critical national infrastructure from cyber-attacks. Under the new Strategy, more efforts are planned to increase skills as well as awareness among enterprises and private individuals around cybersecurity.

This Strategy makes reference to the fact that some government Departments and Agencies can readily demonstrate compliance with international best practice and international standards like ISO 27001[15].

[13] https://enterprise.gov.ie/en/Publications/Publication-files/Irelands-Industry-4-Strategy-2020-2025.pdf
[14] https://www.gov.ie/en/publication/f4a16b-national-digital-strategy/
[15] https://www.gov.ie/en/publication/8994a-national-cyber-security-strategy/

Future Jobs Ireland 2019

Future Jobs Ireland was published in 2019 by the Department of Enterprise, Trade and Employment in response to significant vulnerabilities that are evident in the domestic economy such as declining productivity levels in SMEs, infrastructural constraints, skills deficits and labour availability. Recognising technological advances and the transition to the low carbon economy presents numerous challenges, but also numerous opportunities as our businesses and workers adapt in a changed economy.

Against this backdrop, the Government has developed Future Jobs Ireland, a framework of focused ambitions which will form a key part of Ireland's future economic agenda over the medium term.

Future Jobs Ireland focuses on five pillars namely:

1. Embracing Innovation and Technological Change;
2. Improving SMEs Productivity;
3. Enhancing Skills, Developing and Attracting Talent;
4. Increasing Participation in the Labour Force; and
5. Transitioning to a Low Carbon Economy.

The priorities focus on the key areas of advanced and smart manufacturing, processing technologies and novel materials as well as supporting deliverables such as extending the Irish Manufacturing Research Centres and highlighting the importance of standardization in Industry 4.0[16].

Technology Skills 2022: 2019

Technology Skills was published in 2019 by the Department of Education. The priority actions outlined in this plan were informed by an Expert Group on Future Skills. That identified a significant growth in demand for high-level ICT skills over the coming years. Consultation with stakeholders from across industry and the education and training sector identified a comprehensive suite of supporting actions which are outlined in the background paper: meeting further demand for training and skills development through new and innovative pathways.

The plan will target specific areas of high demand which the Expert Group on Future Skills Needs highlighted, including data analytics, artificial intelligence, robotics, animation among others.

Technology Skills 2022 will place a strategic focus on fully utilising the range of learning opportunities available across the education and training system to meet high-level ICT skill needs by:

- Expanding higher education provision;
- Delivering a progression pathway in further and higher education;
- Expansion of ICT apprenticeships;
- Re-skilling professionals in the ICT sector through Skillnet Ireland; and
- Recruitment of international talent[17].

Food Wise 2025

Food Wise 2025 sets out a ten-year plan for the agri-food sector. It underlines the sector's unique and special position within the Irish economy, and it illustrates the potential which exists for this sector to grow even further and focuses on sectoral growth in the following areas:

- Dairy Sector Post Quota Regime;
- Meat Sector;
- Prepared Consumer Foods (PCF) Sector;
- Seafood Sector;
- Whiskey and Craft Beer Sector;
- Horticulture;
- Forestry; and
- Tillage/Cereals[18].

[16] https://enterprise.gov.ie/en/What-We-Do/Business-Sectoral-Initiatives/Future-Jobs/
[17] https://www.gov.ie/en/publication/554904-technology-skills-2022/
[18] https://www.gov.ie/en/publication/a6b0d-food-wise-2025/

Programme for Government: Our Shared Future

The current 2020 Programme for Government states that part of the National Digital Strategy will be to '*Further develop Ireland's leadership in new digital technologies, including cloud computing, data analytics, blockchain, Internet of Things and Artificial Intelligence'.* They will commence a public consultation on the National Digital Strategy, with a view to completing and publishing it within six months. That Aims:

- To examine changes to the tax system to encourage the efficient use of resources;
- Create a Circular Economy Unit in Government, to ensure a whole-of-government approach to the Circular Economy;
- At automating and digitising construction through design tools and the digital scanning of properties; and
- Increase the number of Science Foundation Ireland (SFI) Research Centres and seek to establish a cross-border research centre, to bring together universities and industry, north and south[19].

[19] https://www.gov.ie/en/publication/7e05d-programme-for-government-our-shared-future/

FUNDING

StandICT.eu

StandICT.eu is a new initiative funded by the European Commission focused on supporting the participation and contribution of EU Specialists to Standard Development Organizations (SDOs) and Standards Setting Organizations (SSOs) activities covering the 5 essential building blocks of the digital Single Market: 5G, Cloud Computing, Cybersecurity, Big Data and IoT. StandICT receives the funding from the European Union's Horizon 2020 framework.

Through a standards watch, StandICT.eu will analyse and monitor the international ICT Standards landscape and liaise with SDOs and SSOs, key organizations such as the EU Multi-stakeholder Platform for ICT Standardization as well as industry-led groups, to pinpoint gaps and priorities matching EU Digital Single Market objectives.

These become the topics for a series of 8 Open calls focused on priority domains and a continuous cascading grants process, launched by StandICT.eu from March 2018, providing support for European specialists to contribute to ongoing standards development activities, and attend SDO & SSO meetings. In 2020 nine experts on NSAI National Mirror Committees received funding.

Disruptive Technologies Innovation Fund

The Disruptive Technologies Innovation Fund (DTIF) is a €500 million fund established under Project Ireland 2040 and is run by the Department of Business, Enterprise and Innovation with administrative support from Enterprise Ireland. The Disruptive Technologies Innovation Fund (DTIF) is about funding collaborations that demonstrate technology-based disruptive innovation, collaborations that can:

- Alter markets;
- Alter the way businesses operate; and
- Involve new products or the emergence of new business models.

Projects must be collaborative in nature, involving a number of partners working together. There will also be a focus on projects that can be commercialised, meaning they can have a real impact on the jobs of the future. SME participation in each collaboration is an essential requirement in order to receive funding from the DTIF.

It is about looking for ideas in areas like Robotics, Artificial Intelligence, Augmented and Virtual Reality, Advanced Manufacturing and Smart and Sustainable Food Production.

Horizon 2020

The European framework programme for R&D, Horizon 2020, focuses on market take-up of research results and innovation. Standardization is identified in Horizon 2020 as one of the measures that will support this.

The role of standardization as a bridge between research activities and the market and has been increasingly recognized, both by EU institutions and by R&D stakeholders.

Horizon Europe

The Commission's proposal for Horizon Europe is an ambitious €100 billion research and innovation (R&I) programme to succeed Horizon 2020.

Horizon Europe is not just about grants to enable European R&I. Spending money would deliver few lasting results if the broader framework for R&I is not effective and efficient. Horizon Europe is also a powerful tool to give direction to European R&I and to European policy. It brings together partners from science, innovation and business, to jointly develop agendas, to divide the work, and to focus on framework conditions such as regulation to improve the R&I ecosystem.

STANDARDIZATION + INNOVATION FOR IMPACT

For countries, organizations and individuals involved in research, innovation and enterprise development across industry, academia and government, there are many benefits of engaging in international standards development for new and emerging technology areas, including Industry4.0. Standards help build customer trust and confidence in new technologies, thereby enabling the accelerated mass-market diffusion and adoption of related products and services. In effect, standards help bridge the innovation gap between research and global markets by enabling efficient and effective knowledge and technology transfer, resulting in maximum socio-economic and environmental benefits and impact. The EU Commission stated the following in relation to standardization[20]:

> *'The development and implementation of research and innovation agendas including through standardization is essential for EU competitiveness. Horizon 2020 will give strong support to the market uptake of innovation, in particular to supporting standardization through research and putting science into standards. Standardization activities are an essential channel for the market adoption of research results and for the diffusion of innovation'.*

At a national policy level, Innovation 2020 and Enterprise 2025 emphasise the importance of standards as a source of competitive advantage to help Ireland fulfil its ambition to become a 'Global Innovation Leader', and state that *'Irish-based enterprises must embed standards in their research, development and testing processes*'. In their recent extensive report on SME productivity and entrepreneurship in Ireland, the Organization for Economic Co-operation and Development (OECD)[21] emphasised the importance of engaging in standards development and use. OECD highlights that '*compliance with standards is underplayed as a lever to support SMEs to upgrade their management practices'*. The report also recommends that Ireland "Increase policy attention to the role that adopting and developing international standards can play in enhancing SME productivity". It also states that Ireland should "Increase support for international standards adhesion by SMEs as an additional lever for encouraging upgrading to international best practice business management approaches".

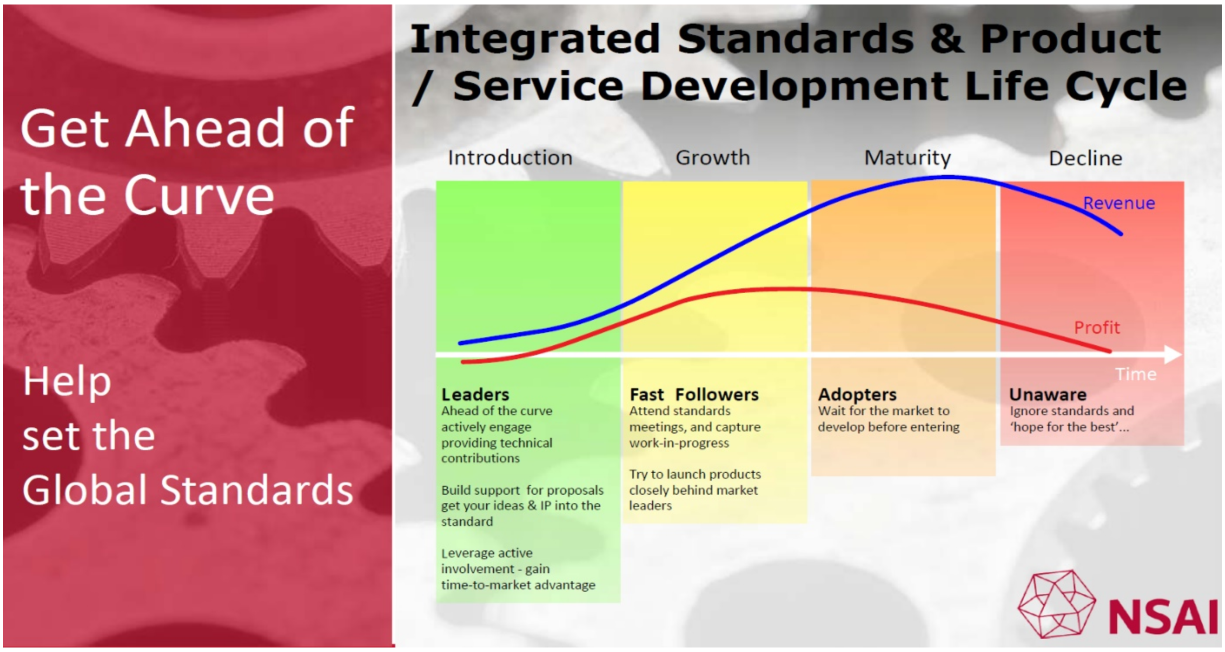

Figure 3: Getting ahead of the curve by early and active engagement in international standards development

Figure 3 above illustrates the Technology Adoption Life Cycle, including the different levels of potential engagement by stakeholders in standards development to either lead, follow, adopt (or ignore) new standards development in support of the latest technologies, innovations and trends. The earlier a company or RDI center engages in the standards development process – integrated within their overall innovation process as illustrated – the sooner they can bring their standards-informed innovation to competitive global markets, resulting in greater rewards. Hence the 'leaders' and 'fast-followers' get ahead of the curve by leveraging their early and active involvement in setting new standards. During

[20] The annual Union work programme for European standardisation for 2017. COM/2016/0357 final
[21] OECD report, 'SME and Entrepreneurship Policy in Ireland', launched 31st Oct 2019

the standards development process, they gain new technical insights and time-to-market advantage over their competitors and have the opportunity to add their own unique product or service innovations on top of the foundational standard that they helped set. Hence standardization leaders and fast-followers are fully prepared to successfully launch their standards-aligned products and services across international markets ahead of their competitors.

As illustrated in the Innovation process figure, the sooner the standards-informed innovation can be brought to competitive global markets, the greater the rewards. Hence the 'leaders' and 'fast-followers' get ahead of the curve by leveraging their early and active involvement in setting new standards. During the standards development process, new technical insights are gained and time-to-market advantage over competitors and have the opportunity to add their own unique product or service innovations on top of the foundational standard that were helped set. Hence standardization leaders and fast-followers are fully prepared to successfully launch their standards-aligned products and services across international markets ahead of their competitors.

Standards + Innovation awards 2020

In 2019, CEN and CENELEC launched the "Standards + Innovation Awards" to acknowledge the important contribution of research and innovation to standardization and celebrating the contributions of researchers, innovators and entrepreneurs to standardization.

In 2020 the founder and CEO at Origin Chain Networks (OCN) Fiona Delaney picked up a prestigious award at the European Committee for Standardization's (CEN and CENELEC) "Standards + Innovation Awards".

Ms. Delaney, who was nominated by the National Standards Authority of Ireland (NSAI), was awarded the accolade for her involvement in standardization in the field of interoperable blockchain infrastructure. Ms. Delaney and OCN submitted a unique agri-food application of blockchain called Universal Farm Compliance to the 'Blockchain and distributed ledger technologies' standards committee.

The use case describes a blockchain-enabled platform available to farmers and agri-compliance bodies, facilitating rapid and near real-time data-sharing. Universal Farm Compliance helps farmers and the entire agri-food ecosystem to implement a safer, more transparent food supply chain, and advances digital transformation in the agri-food industry.

Digital Innovation Hubs (DIHs) in Europe

The European Commission is investing in Digital Innovation Hubs as means to support businesses in their digital transformation and is promoting cooperation among them.

Digital Innovation Hubs (DIHs) can help ensure that every company, small or large, high-tech or not, can take advantage of digital opportunities. DIHs are one-stop shops that help companies become more competitive with regards to their business/production processes, products or services using digital technologies. DIHs provide access to technical expertise and experimentation, so that companies can "test before invest". They also provide innovation services, such as financing advice, training and skills development that are needed for a successful digital transformation. See Link for list of Ireland's DIHs.

Research Centres in Ireland

Research centres in Ireland help in fusing new technologies into the production process to improve manufacturing performance via automation, data analytics, 3D printing and Robotics. These partnerships between Fellows, Postdocs, PhDs, Masters, & PDRAs and industry can:

- Offer expertise and experience in Academic and Industrial settings;
- Help to address crucial research questions;
- Promote the development of new and existing companies to create innovative products; and
- Encourage early adoption of emerging technologies.

Research Centres work collaboratively with industry to drive business readiness for Industry 4.0. There have been many successful case studies showing how these research centres have identified new pathways using emerging technologies to save both time and cost while also expanding production.

For the full list of Ireland's Research Centres see the Knowledge Transfer Ireland website.

TOWARDS AGILE STANDARDIZATION: TESTBEDS IN SUPPORT OF STANDARDIZATION – CONCEPT & EMERGING PRACTICE

The digital transformation of industry across all sectors poses multiple challenges to traditional standardization, due to the complexity, dynamics, and accelerating speed of technological progress.

> *'The need for a timely availability of standards calls for new approaches and tools to enhance standardization processes. Industry and standards development organizations worldwide are seeking new solutions. Testbeds or test labs have been acknowledged in innovation policy as a powerful tool for knowledge transfer and the further development of emerging technologies. Lately, they have also attracted increasing attention from the standardization perspective as a promising tool for a more agile standards development process. Proponents of such testbeds expect them to support standardization by providing validated solutions and accelerating the processes to meet the growing demands for faster standardization without any detriment to quality'*[22].

In addition, according to the European Platform of National Initiatives on Digitising Industry, '*The development of digital industrial platforms relies on testing and experimentation facilities. It grows an ecosystem of developers and users across value chains, including SMEs, and accelerates the emergence and validation of standards by industry'*[23].

The figure below from the *German Standardization Roadmap Industry 4.0*[23] illustrates the above concept, including the 2-way interaction between 'Standardization' and 'Testlabs', all guided at a German national policy level via a strategic policy oversight body 'Platform Industrie 4.0'.

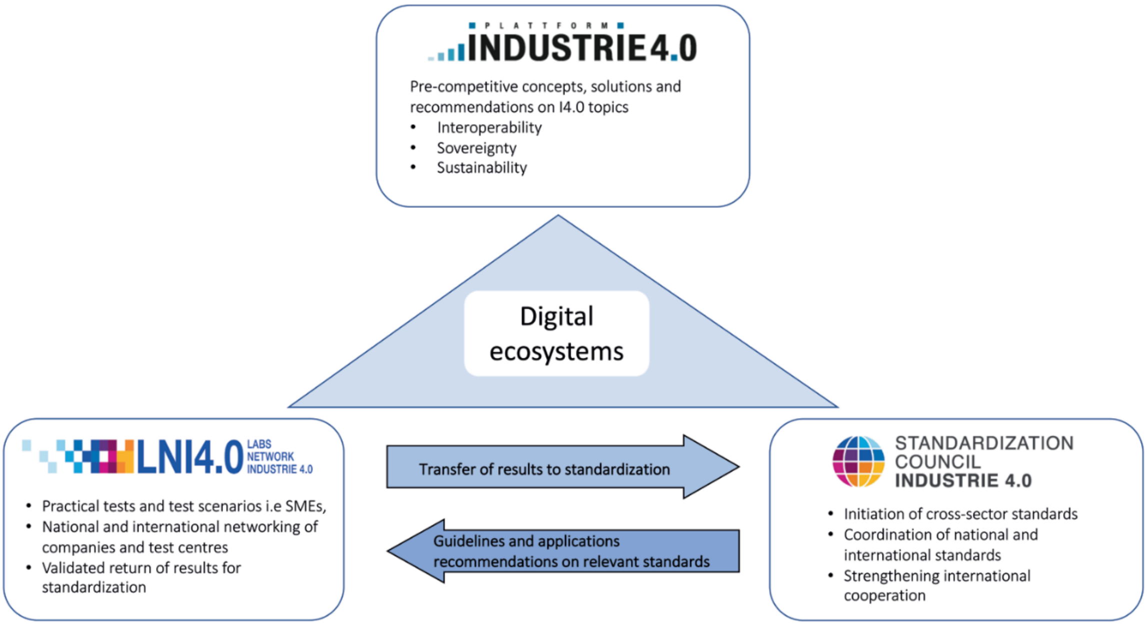

Figure 4: Link between Standardization and Testlabs German Standardization Roadmap Industry 4.0**.**

A recent academic paper - *Towards Agile Standardization: Testbeds in Support of Standardization for the IIoT*[24] - illustrates how testbeds can positively affect standardization at different stages of the standard development process. The paper included a study of 10 existing testbeds based in Germany, China and USA.

As illustrated in the figure below, the process starts with the identification of a standards need or gap during new technology or product development in testbeds, which results in the potential initiation of a new standardization project. Ongoing feedback loops are established at all stages between the testbeds

[22] Towards Agile Standardization: Testbeds in Support of Standardization for the IIoT. Claudia Koch and Knut Blind, IEEE Transactions on Engineering Management. July2020

[23] German Standardization Roadmap Industrie 4.0 Version 4 July 2020

[24] Towards Agile Standardization: Testbeds in Support of Standardization for the IIoT. Claudia Koch and Knut Blind, IEEE Transactions on Engineering Management. July2020

and the standards development process via the relevant standards technical committees. This in turn enables the ongoing validation and editing of the draft standards as they progress through the various drafting stages through to final publication - thereby achieving better standards faster. Even following the publication of a standard, testbeds can demonstrate the practical implementation of the standard to industry users and enable the broad diffusion and adoption of the standard. Furthermore, changing technical requirements can be identified continuously via the testbeds and fed back into the standards committees, resulting in potential revisions to evolving standards.

As a result, the entire standards development process and lifecycle can become more agile in order to meet the demands of a rapidly evolving technology landscape.

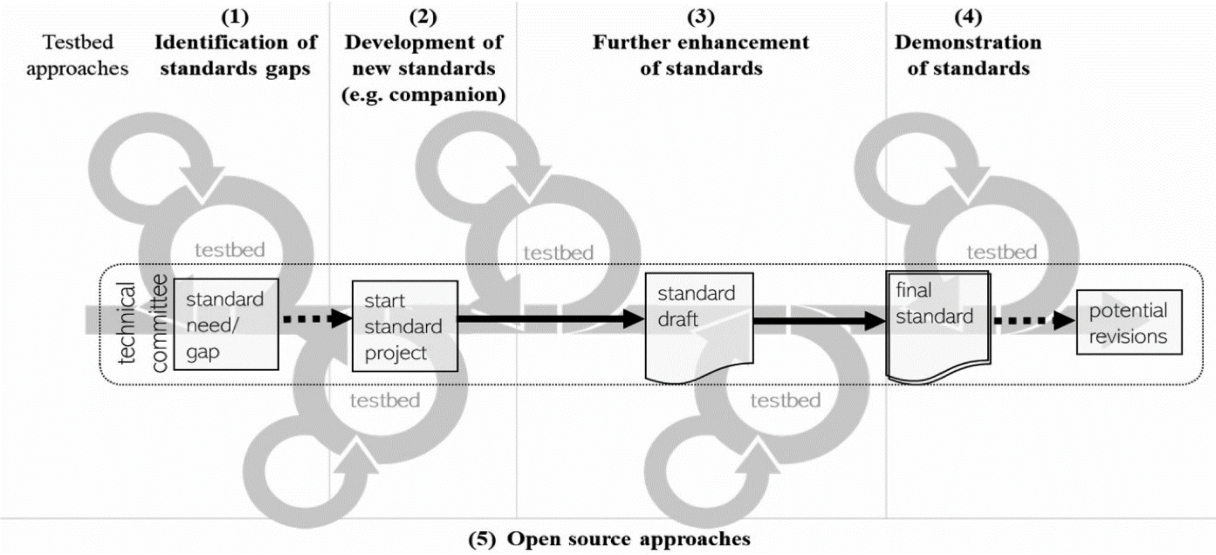

Figure 5: Agile standardization process enabled through testbeds (located in 'Digital Innovation Hubs' / RDI Centres)[25]

In summary, the above 'Integrated Standards Development & Testbeds' approach can contribute to more agile standardization that meets the requirements of rapidly changing complex technologies. Providing validated solutions to standards development allows for a faster definition of standards with no detriment to high quality. Additionally, the infrastructures and processes of Standards Development Organizations may need to be adapted to effectively and efficiently exploit the opportunities provided through testbeds.

[25] Towards Agile Standardization: Testbeds in Support of Standardization for the IIoT. Claudia Koch and Knut Blind, IEEE Transactions on Engineering Management. July2020

GERMAN STANDARDIZATION ROADMAP INDUSTRY 4.0 – Version 4

The German Standardization roadmap industry 4.0 version 4 was published in July 2020 and is continuously developed by the Standardization Council Industry 4.0 as well as DIN and DKE. It is a guide showing the way for individuals and organizations active in various sectors of technology and presents the outcomes from current work and discussions, as well as an overview of standards and specifications relevant to Industry 4.0. It sketches out the requirements placed on standardization and lays down effective measures for their successful implementation, while formulation recommendations for standardization. This standardization roadmap deals with interoperability and how to achieve it, which may be of benefit to Irish SME's.

Industrial Security

Corporations are always at a risk of intrusion and information leakage hence vast knowledge in security and protection is required to execute and manage their systems. Especially nowadays with IIoT technologies, remote working and the protection of applications supported by artificial intelligence mechanisms. These all create additional risks of intrusion and further security requirements need to be considered.

Current Developments

Below are listed the Technical Committees, Sub- Committees and Working Groups from the German Standardization Roadmap Industry 4.0 version 4, that are currently involved in standardization in the field of Industrial Security.

→→IEC/TC 65/WG10: Standardizing IEC 62443;
→→ IEC/TC 65/SC 65E/WG 8: OPC: Client/Server SW Interface inclusive security;
→→ IEC/TC 65/WG 23 Taskforce Cyber Security: Identify cyber security relevant smart manufacturing scenarios and requirements;
→→ IECEE CMC WG31 Cyber Security Certifications;
→→ ISO/TC 292/WG4: Authenticity, Integrity & Trust for Products and Documents/Anticounterfeiting;
→→ ISO/TC 292/WG8: Supply Chain Security;
→→ JTC1/SC27/WG3 Security evaluation, testing and specification;
→→ JTC1/SC27/WG4 Security controls and services;
→→ JTC1/SC 31 Automatic identification and data capture techniques;
→→ JTC1/SC 41 Internet of Things and related technologies;
→→ JTC 1/SC 42 Artificial Intelligence; and
→→ JTC1/WG 13 Trustworthiness.

Recommendations

Listed below are the recommendations from the German Standardization Roadmap Industry 4.0 version 4 for the key area of Industrial Security:

1. Harmonisation of the EU Cybersecurity Act and New legislative Framework;
2. Security infrastructure for secure inter-domain communication;
3. Security for agile systems;
4. Methods for determining the security characteristics of composite products based on the security characteristics of the contained/interacting components;
5. Access, roles and authorization mechanisms for Industry 4.0;
6. Security standards for the exchange of type and instance information of administration shells;
7. Standardized security development process for integrators and operators;
8. Generic interface for security elements in embedded systems; and
9. 5G Security for Industry[26].

[26] German Standardization Roadmap Industrie 4.0 Version 4 July 2020

Functional Safety

Functional safety is an important component of risk reduction. The aim of functional safety systems is to reduce the operational risk of a facility in cases where it is too high to fall below the acceptable operational risk (marginal risk). The requirements for functional safety systems cover all life cycles of a facility, from initial design considerations to decommissioning and disposal of a facility. The functional units to be considered in connection with functional safety cover the entire range of functions required for risk reduction, including actuators, logic processing (control), sensors and all necessary interfaces and installations. In addition, function-restricting external influences, such as failure of the auxiliary power supply (electrical, but also hydraulic and pneumatic) must be taken into account.

The following are selected existing safety standards with functional safety requirements from the German Standardization Roadmap Industry 4.0 version 4:

→→ I.S. EN ISO 12100: Safety of machinery – General principles for design – Risk assessment and risk reduction;
→→ I.S. EN 61508-1: Functional safety of electrical, electronic, programmable electronic safety-related systems;
→→ I.S. EN 61511-1: Functional safety – Safety instrumented systems for the process industry sector;
→→ I.S. EN ISO 13849-1: Safety of machinery – Safety-related parts of control systems;
→→ I.S. EN 62061: Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems;
→→ I.S. EN IEC 61131: Programmable controllers;
→→I.S. EN ISO 13850: Safety of machinery – Emergency stop function;
→→ I.S. EN 50156-1: Electrical equipment for furnaces and ancillary equipment; and
→→ I.S. EN ISO 23125: Machine tools – Safety – Turning machines.

Recommendations

Numbered below are a set of recommendations in the area of Functional Safety from the German Standardization Roadmap Industry 4.0 version 4:

1. The implementation of the Industry 4.0-concepts leads to a further modularization of plants and components with great effects also on the engineering process. It should be considered how Industry 4.0-concepts can also take into account plant safety and functional safety issues. This can be done by extending the concept of the administration shell to a “safe administration shell”.
2. Standardized procedures and methods should be developed to enable on-time risk management throughout the life cycle without compromising the confidentiality of the technical documentation. In accordance with the most recent German-Chinese agreements, a guideline should first be developed (Sino-German Whitepaper on Functional Safety in Industry 4.0), which sensitizes the stakeholders with regard to the possible repercussions (risk increases or compromise of risk-reducing measures) of different Industry 4.0 application scenarios on plant safety.
3. The effects of the use of AI systems in an industrial environment on plant safety should be considered. Current findings of AI research and application, e.g. explainable AI, should be considered as to what extent safety requirements can be met when using AI and how these requirements can be described in standards.
4. The work on safety and security should be further deepened and made more concrete. This should be done as part of the revision of S.R. CLC IEC TR 63069. A further development towards publication as a Technical Specification (TS) or an International Standard (IS) should be discussed.[27]

[27] German Standardization Roadmap Industrie 4.0 Version 4 July 2020

STANDARDS AND REGULATIONS

Figure 6 illustrates how standards support organizations, including SMEs, to comply with European technical regulations across many sectors and product categories, including ICT products and services in the context of the EU Digital Single Market. ICT Standards play an essential role in achieving interoperability of new technologies and can bring significant benefits to both industry and consumers. They help ICT markets remain open and allow consumers the widest choice of products.

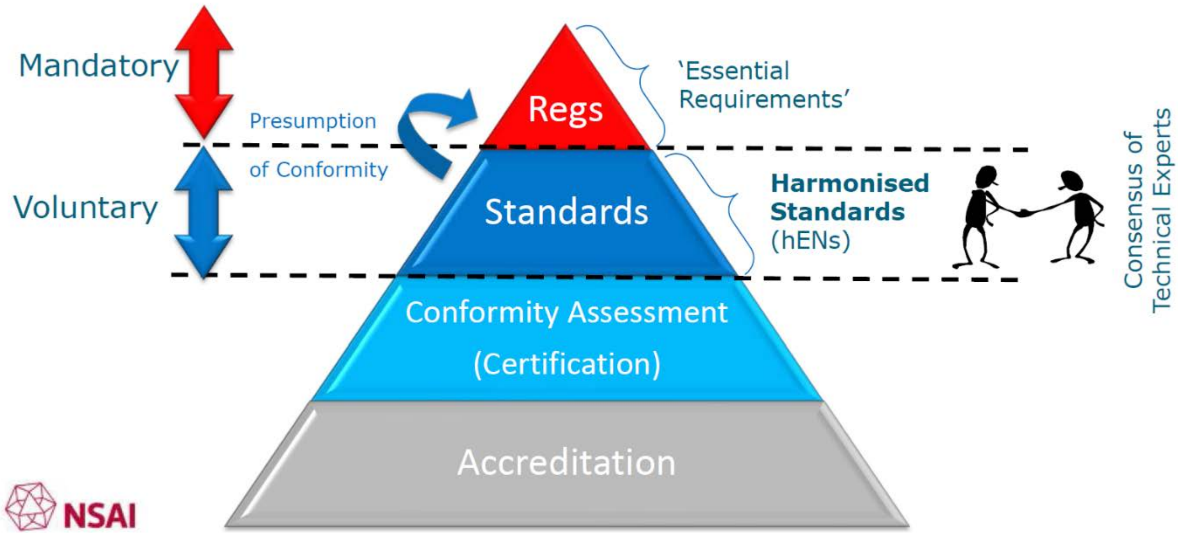

Figure 6: Links between Regulations, Standards & Certification

Harmonised standards

Harmonised standards establish technical specifications which are considered suitable or adequate in order to comply with the technical requirements given in EU legislation. Compliance with harmonised standards provides a presumption of conformity with the corresponding requirements of harmonisation legislation. Manufacturers, other economic operators (business or other organization which supplies goods, works or services within the context of market operations) or conformity assessment bodies can use harmonised standards to demonstrate that products, services or processes comply with relevant EU legislation.

The references of harmonised standards must be published in the Official Journal of the European Union (OJEU).

In the CEN-CENELEC Work Programme 2021 CEN-CENELEC are committed to the timely citation of harmonised standards (hENs) in the Official Journal of the EU. Harmonised standards are high priority and are particularly significant, especially for SMEs helping them access the European Market by providing them with legal certainty and reducing the administrative burden.

MACHINERY DIRECTIVE

The Machinery Directive 2006/42/EC of the European Parliament and of the Council of 17th of May 2006 is a European Union directive concerning machinery and certain parts of machinery. Its main intent is to ensure a common safety level in machinery placed on the market or put in service in all member states and to ensure freedom of movement within the European Union by stating that "member states shall not prohibit, restrict or impede the placing on the market and/or putting into service in their territory of machinery which complies with [the] Directive".

Scope

This Directive applies to the following products:

(a) Machinery;

(b) Interchangeable equipment;

(c) Safety components;

(d) Lifting accessories;

(e) Chains, ropes and webbing;

(f) Removable mechanical transmission devices; and

(g) Partly completed machinery.

Revision

In January 2019 revision started on the Machinery Directive due to the need for improved safety levels to take account of the latest ICT innovations and emerging technologies such as Industrial Internet of Things (IIoT), AI and improved robotics.

The document "Impact assessment study on the revision of Directive 2006/42/EC on machinery"[28] published by the European Commission in 2019 offers a comprehensive view into aspects such as AI, AI in Robotics, IIoT, Cybersecurity, along with the barriers of the current Machinery Directive (MD) and approach of the sector today.

AI

AI is expected to contribute to an increase in global GDP of EUR 13.8 trillion in 2030, while the AI software market is expected to grow from EUR 1.2 billion in 2016 to EUR 52.5 billion by 2025. The forecasted cumulative revenue between 2016 and 2025 in the segment of machine/vehicular object detection/identification/avoidance within AI is the largest with USD 8,986 million. Data on AI investment varies according to the category assessed. The top 10 countries investing into AI globally are China, the USA, India, the UK, Canada, Sweden, Israel, Germany, Spain and France.

Technological innovation generated by programming and automatic process management and improved capabilities through AI and machine learning are expected to take manufacturing to the next level, particularly regarding speed, scale and convenience. AI's ability to automate industrial operations will contribute to increasing speed and scale, reducing the time invested in jobs among others. In 2024, the expected market size of AI in industrial machines will be about USD 415 million (EUR 364.5 million) globally.

AI in Robotics

AI technology may be used in robotics as well, as indicated above. For instance, robotic process automation are machines that are programmed to perform high-volume and repeatable tasks that are normally performed by persons and that can also adapt to changing circumstances. Robotics is a booming industry, with innovation focusing on introducing new ways for robots to interact with the environment and those changing circumstances. More specifically, robots are increasingly able to read the environment around them, thus anticipating and reacting to change, and to integrate with it. As a result, new cooperative robots are moving beyond traditional physical fences to cooperate directly with humans, while also taking on more complex tasks in other application areas (i.e. services robots).

[28] https://op.europa.eu/en/publication-detail/-/publication/57914c1d-ebfb-11ea-b3c6-01aa75ed71a1/language-en

IIoT

IIoT leverages the power of smart machines and real-time analytics to take advantage of the data that machines have produced in industrial settings for years. While IIoT is still in its beginnings, manufacturing is considered the largest market to be affected by developments in this area, considering that a smart production unit could consist of a large connected industrial system of materials, parts, machines, tools, inventory and logistics that are connected to each other. Smart manufacturing ranked fourth in terms of growth potential after smart energy, smart health and smart transport, and third in terms of the EU's industry potential. IIoT is projected to increase global GDP by about USD 15 trillion (EUR 12 trillion) by 2030. While in 2014, only about 10% of the industrial machines were connected, the projections indicate a steep growth in uptake in the future. In comparison to overall IoT, the number of IIoT connections is expected to increase by 70.5% from 2016 to 2025. Comparing the number of expected active IIoT connections (8.03 million) to the total expected IoT connections (5 billion), IIoT will account for around 0.16% of all the connections in 2020.

Cybersecurity

Cybersecurity runs across all types of emerging technologies used in the scope of machinery. Unless there is an adequate separation from the machine's control and safety systems there will be a risk of malfunction either due to inadvertent interference or deliberate and malicious hacking. Examples of incidents leading to physical asset damage due to cyber-attacks on operational technology are listed by the OECD.

Most mitigation actions to tackle these vulnerabilities are software updates that minimise or remove the weaknesses or vulnerabilities. However, the possibility to upload software remotely to machinery raises concerns with regards to safety because of aspects of cybersecurity and overall cyber-physical security. Remote updates create potential opportunities for malicious third parties to intercept and replace legitimate software with malware that could affect the machinery's operations and hence have an impact on safety. The increasing role of software in the once hardware-dominated world of machinery requires the consideration of new specific risks.

Shortcomings, barriers of the current Machinery Directive (MD) and approach of the sector today

- First, the MD makes no explicit mention of the required testing environment of self-driving Robots;
- Second, there is currently no regulation on the governance and usage of social robots. As social robots are used in sensitive human-system interactions such as educational facilities and private homes, the possibility of unintentional behavioural dysfunctions as a reaction to specific external inputs raises concerns of essential health and safety requirement conformity;
- Third, the MD does not sufficiently cover potential physical and mental health risks arising from human-robot collaborations;
- Fourth, the MD does not cover relevant aspects of data privacy of social robotics which can have an impact on the mental health of human operators;
- Fifth, the MD does not specify situations in which robots' autonomy needs to be curtailed in favour of human control; and
- Sixth, the MD does not currently specify the conditions and manner in which specific safety or trust-relevant information should be made visible to the human user on a human machine interface system[29].

[29] https://op.europa.eu/en/publication-detail/-/publication/57914c1d-ebfb-11ea-b3c6-01aa75ed71a1/language-en

MACHINERY WORKING GROUP

The Machinery Working Group is the most frequently used forum to discuss the practical application of the Machinery Directive at EU level. It is composed of representatives of all relevant stakeholders: National Authorities, Standardization Bodies, Notified Bodies, Industry Associations, etc.

In November 2020 the Machinery Working Group shared their proposals for the future revision of the Machinery Directive which are outlined below[30]. The first draft of the revision should be available from the European Commission by March 2021 with a view to have it published by the end of next year.

Protection against corruption

- The machinery must be designed and constructed so that the connection to it of another device, by any feature of the connected device itself or by any remote device that communicates with the machinery does not lead to a hazardous situation.
- A hardware component that is critical for the machinery compliance with the relevant health and safety requirements shall be designed so that it can be secured. Security measures foreseen shall provide for evidence of an intervention.
- Software that is critical for the machinery compliance with the relevant health and safety requirements shall be identified as such and shall be secured.
- Software identification shall be easily provided by the machinery.
- Evidence of an intervention shall be available for a reasonable period of time.
- Machinery data, software that is critical for the machinery compliance with the relevant health & safety requirements shall be adequately protected against accidental/intentional corruption.

Safety and reliability of control systems

Control systems must be designed and constructed in such a way as to prevent hazardous situations from arising. They must be designed and constructed in such a way that the machinery with fully or partially evolving behaviour or logic:

a) must be intrinsic safe and must under all circumstances not be permitted to make decisions concerning life, injury and death of persons and damage to material and surroundings;

b) must not cause the machine to perform actions that exceed its defined task and movement space;

c) if taking incorrect decisions, the machinery placed on the market and new machinery to be placed on the market, must be correctable, to prevent any future recurrences of that particular error;

d) the actions must be traceable in advance and retrospectively, based on transparency of the datasets used, as well as of the test environments and of the decision frameworks or assessment criteria for algorithm-based decisions for conformity assessment and market surveillance purposes; and

e) the decision-making process must be logged and retained for conformity assessment and market surveillance purposes.

Technical file for machinery

The technical documentation shall include at least the following elements:

a) during the use of specific machinery categories with sensor-fed, remotely-driven, autonomous, AI with learning capability, if the operations are alimented by (sensorial) data, or if the software can evolve by itself, the trace log of all relevant elements – both the data and the versions of software - should be collected and kept synchronized for an eventual ex-post inspection; and

b) where appropriate, the source code or programmed logic that are safety-related, together with the relevant data, should be collected and kept synchronized to allow failure analysis or in case of inspection.

Principles of human centric principles

Machinery shall remain subject to an appropriate level of human oversight and be designed and implemented in such a way that its functioning can be controlled and overseen by humans. Human oversight shall include the ability of humans to override or reverse the outputs of artificial intelligence and prevent its further use.

[30] Revision of the Machinery Directive 2006/42/EC Machinery Working GroupBrussels, 9-10 November 2020

STANDARDS & THE STANDARDIZATION PROCESS

While the industry and the research community are challenged by the technical issues of Industry 4.0, government, policy makers and the legislature also need to consider the ethical and societal issues. standards that establish requirements and guidelines for terminology, ethics, bias and risk will therefore support all stakeholders in the design, development and deployment of Industry 4.0 driven technologies.

Furthermore, evolving international standards for Industry 4.0 have the potential to influence and support the uptake and implementation of Industry 4.0 technologies in all industries and sectors and also help to develop the confidence and trust of consumers and society as a whole.

Technical Standardization is widely recognized for its ability to provide authoritative technical requirements and recommendations for technologies, products, services and processes. Standards are developed within standardization bodies that bring together all interested stakeholders at the relevant National, European and at International Level, as illustrated in Figure 7. The International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and the International Telecommunication Union (ITU-T) are the three recognized Standards Development Organizations (SDOs) at the international level. Likewise, the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI) are the three recognized European Standardization Organizations. At national level, each country has a National Standards Body (NSB) that works for the interests of the country and co-ordinate with European and International Standardization Organizations. In Ireland, NSAI is the NSB and is a member of CEN, CENELEC, ETSI, ISO, IEC. Through this membership, NSAI is the gateway to international standards development for all individuals and organizations based in Ireland[31].

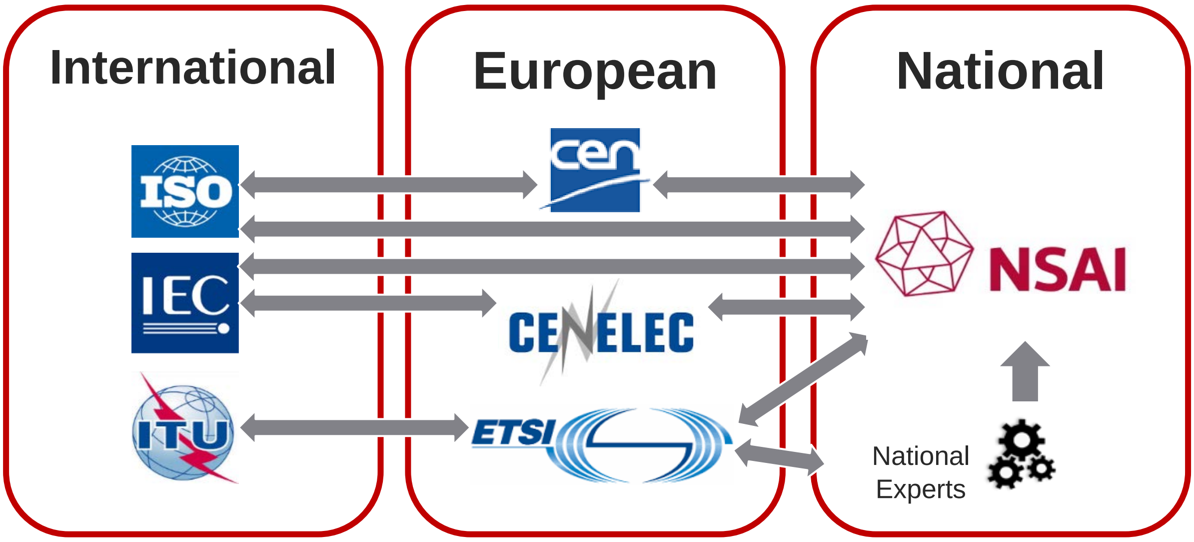

Figure 7: The Network of Standards Organizations

[31] White Paper - INTERNET OF THINGS (IoT) - ILNAS

ELEVEN ENABLING TECHNOLOGIES DRIVING INDUSTRY 4.0.

The following emerging technologies are significant in the development of Industry 4.0 with standards enabling their uptake through reference architecture models, uses cases and specifications, all while facilitating interoperability by providing standards that will be the backbone of the transition to Industry 4.0[32].

▪ Functional Safety

Functional safety relies on active systems that can respond to a potentially dangerous situation. It has transformed the landscapes of factories, making them a much safer place to work. It has also enabled automation in manufacturing replacing human operators in dirty, dangerous, and dull jobs and reduced repetitive strain and accidental injuries.

The more basic concept in functional safety is that of a safety function. A safety function defines an operation that must be carried out to achieve or maintain safety. A typical safety function contains an input subsystem, a logic subsystem, and an output subsystem. Typically, this means that a potentially unsafe state is sensed, and something makes a decision on the sensed values and, if deemed potentially hazardous, instructs an output subsystem to take the system to a defined safe state.

Industry 4.0 offers a new vision for the factories of the future. In these factories of the future, safety will be critical. Functional safety addresses confidence that a piece of equipment will carry out its safety functionality when required to do so. It is an active form of safety in contrast to other forms of safety. Integrated circuits are fundamental in the implementation of functional safety and, therefore, to Industry 4.0. The implications of functional safety for Industry 4.0 include requirements for networks, security, robots/cobots, software, and the semiconductors used to implement these features.

Standards

Machine safety standards are structured in a "type ABC" Structure.

Type-A Standards (basic safety standards) – These give basic concepts, principles for design, and general aspects that are applicable to machinery.

Type-B Standards (generic safety standards) – Deal with one specific aspect of machinery safety or specific types of safeguard that can be used across a wide range of categories of machinery.

Type-C Standards (machine safety standards) – Provide specifications for a given category of machinery. The different types of machinery belonging to the category covered by a C-type standard have a similar intended use and present similar hazards.

The basic functional safety standard is IEC 61508-1.

The first revision of this standard was published in 1998, with revision two published in 2010 and work beginning now to update to revision 3 for 2020. Since the first edition of IEC 61508 was published in 1998, the basic IEC 61508 standard has been adapted to suit fields such as automotive with ISO 26262-2 process control with IEC61511-3 programmable logic controls with IEC 61131-6 machinery with IEC 62061 variable speed drives with IEC 61800-5-2 and many other areas. These other standards help interpret the very broad scope of IEC 61508 for these more limited fields. An important parallel standard not derived from IEC 61508 is ISO 13849 which covers machinery that is derived from the obsolete European Standard EN 954 .

The diagram below depicts some of the more relevant Functional Safety Standards.

[32] https://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/policy_briefs/INDUSTRY_4.0_Policy_Brief.pdf

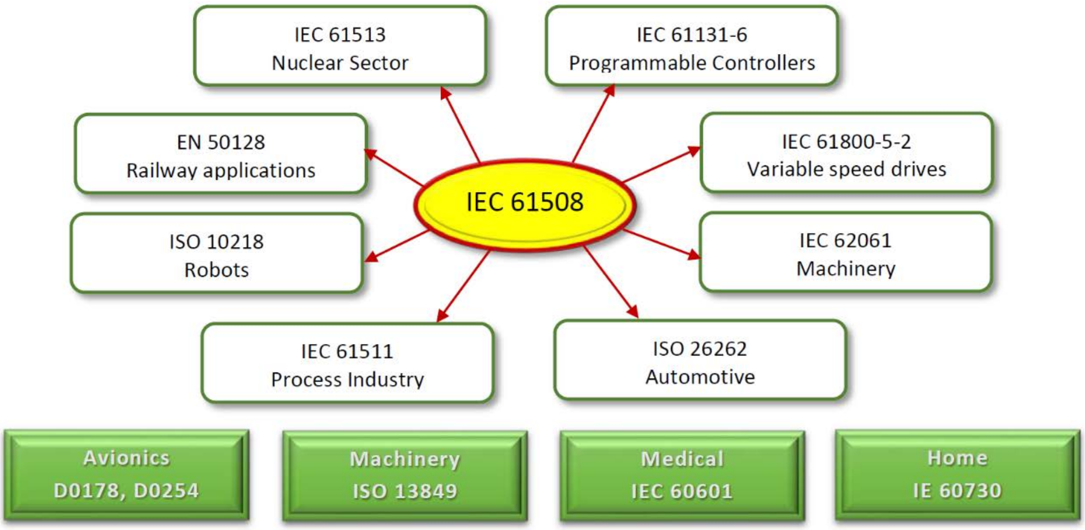

Figure 8: A sample of Functional Safety Standards

IEC 61508 is what is referred to as an A level or basic standard. It is meant to be non-application specific and to be a general standard. From it are derived sector specific standards such as ISO 26262 for automotive or IEC 62061 for machinery. These sector specific standards are referred to as level B standards. The bottom tier of standards are level C standards and apply to specific pieces of equipment.

There are also some standards such as ISO 13849 or the avionics standards such as D0-254/D0-178C which are not derived from IEC 61508 but if you look at the table of contents in any of these you will note that they cover all the same areas and topics as IEC 61508. Some of these standards such as ISO 13849 refer back to IEC 61508 for complex technology or in the case of the medical standards for the detailed software techniques. Others such as the robot safety standard ISO 10218-1 give SIL and PL from IEC 61508 and ISO 13849 to specify the safety integrity requirements.

IEC TC 65/SC 65A/MT 61508-1-2 - Maintenance of IEC 61508-1, -2, -4, -5, -6 and 7

IEC 61508 is the basic safety standard for complex electronics used in control systems. The most recent version from 2010 does not recommend the use of AI in safety systems, the ban is badly worded because of a lack of AI expertise on the committee at the time. The 3rd edition of IEC 61508 will be published sometime around 2021/2022.

AI is already used in mobile robots for navigation, but the safety of such systems still relies on traditionally programmable systems and laser scanners. The use of AI in such safety systems would allow humans and other robots be distinguished and the direction of travel of humans be identified, improving the capabilities of robots and allowing them to run faster and operate for longer.

Issues with using AI in safety systems include:

1. How do you use development flows from standards such as IEC 61508 and ISO 26262?

Normally there is a set of requirements which results in the development of lines of code which can be verified against those requirements. However, with AI you may have a set of training data and no real idea as to how it meets the requirements.

2. How to know that your training data covers all the environmental requirements?

For instance, in self-driving cars they have tried to address this by having hundreds of cars driving around on roads. The number of hours needed could be as high as 800 billion and industrial robot environments might be more controlled, meaning that even more hours of training data could be needed.

3. How to know if the system was hacked?
4. Who is liable if someone gets hurt?

Activity across standards groups:

- IEC TC 65/SC 65A/MT 61508-1-2; – Industrial-process measurement, control and automation

Maintenance of IEC 61508-1, -2, -4, -5, -6 and -7;

- IEC TC 65/TC 65A/MT 61508-3 – Industrial-process measurement, control and automation

Maintenance of IEC 61508-3, -4, -6 and -7;

- ISO/IEC/JTC1/SC 42 Artificial intelligence;

Are involved in standardization work in the area of Functional safety and AI systems.

- ISO TC 299;

Have recently confirmed ISO 13482:2014 Robots and robotic devices — Safety requirements for personal care robots.

Functional safety has a lot to offer Industry 4.0, not just because safety is an essential element of future factories, but also because functional safety has the techniques to enable higher reliability, diagnostics, resilience and redundancy. Going forward, the opportunities and challenges before Industry 4.0 becomes a reality and a success will be interesting to behold.

▪ Robots

Robots are becoming cheaper, less difficult to programme, more connected and agile. Industrial robots can now have many safety-related functions and have been taken out of their cages. These additions have been spurred by improved ease of use, the topic of collaborative operation and the introduction of robots with power and force limiting capabilities. Robots can now be seen on most production floors preforming task such as:

Arc welding, Spot weld, Materials Handling, Machine Tending, Painting, Picking, Packing and Palletizing, Assembly, Mechanical Cutting/Grinding/Polishing and Gluing/sealing or spraying.

Advances in robotics technology also allow us to take robots from the factory floor and make them mobile and autonomous for brand new applications, such as in retail. Where in China the Alibaba supermarket chain is using robotics to double their stores as distribution centers. In other industries, such as agriculture, robotic drones can examine a field to find deficiencies in crops and Robots can be used for weed control, harvesting, sorting and packing and robots are helping farmers collect vital information about soil temperature, composition, moisture and plant health.

Going forward, manufacturing companies will be able to choose whether to automate their tasks completely with a production robot or use a hybrid system. In this system, robots work in harmony with humans (Collaborative Robotics). Collaborative Robots are now easy to programme, fast to setup, they have flexible deployment and can help replace human operators in dirty, dangerous, and dull jobs to reduce repetitive strain and accidental injuries.

Collaborative robotics

In collaborative robotics, humans and robotic equipment can have an overlapping workspace where both perform tasks. Currently ISO/TS 15066 provides guidelines for the design and implementation of a collaborative workspace that reduces risks to people. It specifies:

- Definitions;
- Important characteristics of safety control systems;
- Factors to be considered in the design of collaborative robot systems;
- Built-in safety-related systems and their effective use; and
- Guidance on implementing the following collaborative techniques: safety-rated monitored stop; hand guiding; speed and separation monitoring; power and force limiting.

The technical specification includes data from a study on pain thresholds of different parts of the human body. This information can be used to develop and implement collaborative power- and force-limited robot applications.

Another way to facilitate human and robot system collaboration is through speed and separation monitoring techniques. In such systems, a minimum safety distance between the robot system and the person is maintained to avoid contact. Imagine a robot system integrated with a protective device that senses humans. The robot system then moves away or “dances” with the human. So, if you take a step forward, the robot system moves one step back. The technical specification offers detailed guidance on maximum allowed speeds and minimum separation distances. It can inspire further advancements of protective device technology as well as the development of materials to soften physical contact, better sensors, improved motion control and other innovations.[33]

[33] https://www.iso.org/news/2016/03/Ref2057.html

ISO/TC 299 Robotics

ISO robotic committee was first created as ISO/TC 184/SC 2 with the title of "Robots for manufacturing environments" in 1983. In 2003, this title was updated as "Robots for industrial environments" to accommodate broader fields than only manufacturing environments. The title was again updated to "Robots and robotic devices" to include not only industrial robots but also non-industrial robots, which were defined as service robots in 2006. With increased robotic activity, greater visibility was needed for better coordination. This resulted in ISO/TC 184/SC 2 being upgraded to be ISO/TC 299 with the title of "Robotics" in 2016.

ISO/TC 299 have formulated standards for performance criteria, safety requirements, mechanical interfaces and vocabulary. The ISO 10218 series is the central safety standard for industrial robots. It consists of two parts: The ISO 10218-1 describes the safety requirements for the robot manufacturer while ISO 10218-2 describes the safety requirements for the robot integrator. The committee is currently revising ISO 10218-1:2011 and ISO 10218-2:2011, in order to make clear that an application can be collaborative and provide clarification around safety functions and what safety functions are required, with an aim to have these standards harmonised with the Machinery Directive. Harmonised standards are European standards or European adopted ISO standards that are used to demonstrate that products, services or processes comply with relevant EU legislation. These can be used for the CE marking process and listed on the declaration of conformity for the product. ISO standards that have not been adopted by a European Standards Organization cannot be used for this process.

The below list are standardization activities that ISO/TC 299 are involved in and may be of interest:

- Robotics — Vocabulary;
- Robots for industrial environments — Automatic end effector exchange systems — Vocabulary and presentation of characteristics;
- Robotics — Performance criteria and related test methods for service robots — Part 4: Lower-back support robots; and
- Robotics — Services provided by service robots — Safety management systems requirements.

For the full list of standards under development view the following Link :

CEN/TC 310 Advanced automation technologies and their applications

The committee has been working since 1990 to ensure the availability of the standards the European industry needs for integrating and operating the various physical, electronic, software and human resources required for automated manufacturing. It works closely with ISO/TC 184 and other committees to achieve international standards wherever possible, in order to meet the needs and opportunities of the global market, as well as establishing common European strategies wherever possible. It is also highly relevant within the fast emerging agri-tech and vertical farming and within traditional farming sectors. It is covered in the work carried out at ISO and IEC level.

ISO/TC 310 are involved in the following standardization activities:

- Robotics - Safety requirements for robot systems in an industrial environment - Part 1: Robots; and
- Robotics - Safety requirements for robot systems in an industrial environment - Part 2: Robot systems, robot applications and robot cells integration.

For the full list of standards under development view the following Link.

▪ Additive Manufacturing & 3D Printing

The process of joining materials to make objects from 3D model data, usually layer-by-layer, as opposed to subtractive manufacturing, which is a process by which 3D objects are constructed by successively cutting material away from a solid block of material used in current manufacturing process such as milling, turning, laser cutting, wire EDM, and carving. Some of the key benefits of additive manufacturing are[34]:

- **Design complexity:** design changes that would often take months using conventional manufacturing methods can be implemented much faster. 3D printing is a cost-effective technology for producing parts with complex geometries. Designs that would otherwise be impossible to produce with conventional manufacturing can now be produced with 3D printing;
- **Shorter lead times:** as 3D printing requires no tooling, manufactures can reduce the time needed to produce parts, bypassing the time consuming and costly tooling production step;
- **On-demand production:** since 3D printing can produce physical parts from digital files in a matter of hours, companies can leverage a new model of manufacturing parts on demand;
- **Mass customization:** no tooling constraints means that products can be built to an individual's specification e.g. Invisalign take scan of consumers mouths and produce braces tailored for individuals using 3D Systems SLA printers; and
- **Light weight:** the ability to print internal strengthening structures allows the maximum strength to weight ratio e.g. the arm for monitors on virgin planes.

Additive Manufacturing is one of the important pillars of Industry 4.0 which automates production process with smart direct digital manufacturing technique. AM has reduced prototyping time or batch production time up to 90% than conventional manufacturing technique. Because of various benefits of additive manufacturing, it has found its applications in all fields ranging from jewelry, automotive, medical, aerospace, manufacturing, tooling, oil & gas, spare parts, chemical and food processing, pharmaceutical, creative part production, and so on the possibilities are endless[35].

ISO/TC 261 Additive manufacturing and ASTM F42

ISO/TC 261 and ASTM F42 are collaborating closely in the development and maintenance of standards on AM (which will be ISO/ASTM standards) and have also established procedures for the quick adoption of ASTM standards. Drafting of standards is not being done in ISO WGs but in Joint Groups (JG) that have been set up, under agreement between both ISO/TC 261 and ASTM F42. These JGs are overseen by the working groups.

Working Groups within ISO/TC 261

ISO/TC 261/WG 1 -- Terminology

ISO/TC 261/WG 2 -- Processes, systems and materials

ISO/TC 261/WG 3 -- Test methods and qualification specification

ISO/TC 261/WG 4 -- Data and design

ISO/TC 261/WG 6 -- Environment, health and safety

ISO/TC 261/JWG 10 -- Aerospace applications

ISO/TC 261/JWG 11 -- Additive manufacturing for plastics

Scope of ISO/TC 261/WG 1 -- Terminology

Standardization of terms and definitions as well as fundamental concepts in the field of additive manufacturing (AM*), as defined in the international standard ISO/ASTM 52900. The following are standards published by WG 1:

ISO/ASTM 52921:2013 — Standard terminology for additive manufacturing — Coordinate systems and test methodologies; and
ISO/ASTM 52900:2015 — Additive manufacturing — General principles — Terminology.

ISO/ASTM 52900:2015 categorizes the following seven additive manufacturing technologies[36]:

[34] https://amfg.ai/industrial-applications-of-3d-printing-the-ultimate-guide/
[35] https://3dincredible.com/how-is-additive-manufacturing-transforming-markets-2/
[36] https://all3dp.com/2/main-types-additive-manufacturing/

1. **Vat photopolymerization**
   Also known as stereolithography (SLA), this is the process by which a liquid is cured by a light source, turning it into a solid. This phenomenon became known as polymerization and was the very first industrial additive manufacturing technology;
2. **Material extrusion**
   This is the umbrella term for all additive manufacturing processes in which material is dispensed through a nozzle to form shapes. The first industrial material extrusion process was invented and patented by Scott Crump in 1989;
3. **Sheet lamination**
   Sheet lamination is the process by which sheets of material are bonded together, layer by layer, to form a 3D object. While the principle behind this additive manufacturing process isn't entirely new, the first sheet lamination machine was produced in 1991 by a company called Helisys;
4. **Powder bed fusion**
   Powder bed fusion processes use a thermal energy source to fuse specific areas of powdered material. This encompasses several commercial processes frequently used for industrial applications;
5. **Binder jetting**
   This process uses two types of material: a powder-base for its build material and a liquid binder agent. Manufacturing starts similarly to that of powder bed fusion, with a levelling roller spreading a thin layer of the powder material over a build platform. A print head, very similar to a traditional inkjet one, moves horizontally and sprays the binder agent material on certain areas of the powder layer;
6. **Material jetting**
   This is the process by which droplets of build material are selectively deposited and cured to form a part; and
7. **Directed energy deposition**
   Directed energy deposition (DED) technologies fuse materials by melting them as they're being deposited. It's a complex manufacturing process that's often used for repair and maintenance.

ISO/TC 261/WG 2 -- Processes, systems and materials

Standardization in the field of additive manufacturing (AM*) processes, hardware and software, materials. The following are standards published by WG 2:

ISO 17296-2:2015 — Additive manufacturing — General principles — Part 2: Overview of process categories and feedstock;

ISO/ASTM 52904:2019 — Additive manufacturing — Process characteristics and performance — Practice for metal powder bed fusion process to meet critical applications;

ISO/ASTM 52907:2019 — Additive manufacturing — Feedstock materials — Methods to characterize metal powders;

ISO/ASTM 52903-1:2020 — Additive manufacturing Material extrusion based additive manufacturing of plastic materials — Part 1: Feedstock materials; and

ISO/ASTM 52903-2:2020 — Additive manufacturing Material extrusion based additive manufacturing of plastic materials — Part 2: Process equipment.

ISO/TC 261/WG 3 -- Test methods and qualification specification

Standardization in the field of tests methods related to Additive Manufacturing. The following are standards published by WG 3:

ISO 17296-3:2014 — Additive manufacturing — General principles — Part 3: Main characteristics and corresponding test methods; and

ISO/ASTM 52901:2017 — Additive manufacturing — General principles — Requirements for purchased AM parts.

ISO/TC 261/WG 4 -- Data and design

Standardization in the field of Data and Design related to Additive Manufacturing. The following are standards published by WG 4:

ISO 17296-4:2014 — Additive manufacturing — General principles — Part 4: Overview of data processing;

ISO/ASTM 52910:2018 — Additive manufacturing — Design — Requirements, guidelines and recommendations; and

ISO/ASTM 52902:2019 — Additive manufacturing — Test artifacts — Geometric capability assessment of additive manufacturing systems.

ISO/TC 261/WG 6 -- Environment, health and safety

Standardization in the field of Environment, health and safety related to Additive Manufacturing. The following are standards published by WG 6:

ISO/ASTM 52911-1:2019 — Additive manufacturing — Design — Part 1: Laser-based powder bed fusion of metal;

ISO/ASTM 52911-2:2019 — Additive manufacturing — Design — Part 2: Laser-based powder bed fusion of polymers;

ISO/ASTM 52912:2020 — Additive manufacturing — Design — Functionally graded additive manufacturing;

ISO/ASTM 52915:2020 — Specification for additive manufacturing file format (AMF) Version 1.2; and

ISO/ASTM 52950:2021 — Specification for additive manufacturing file format (AMF) Version 1.2.

ISO/TC 261/JWG 10 -- Aerospace applications

Joint Working Group with ISO/TC 261 and ISO/TC 44/SC 14 (Welding and allied processes/ Welding and brazing in aerospace).

Standardization in the field of Additive manufacturing in aerospace applications. The following are standards published by JWG 10:

ISO/ASTM 52941:2020 — Additive manufacturing — System performance and reliability — Acceptance tests for laser metal powder-bed fusion machines for metallic materials for aerospace application; and
ISO/ASTM 52942:2020 — Additive manufacturing — Qualification principles — Qualifying machine operators of laser metal powder bed fusion machines and equipment used in aerospace applications.

Scope of ISO/TC 261/JWG 11 -- Additive manufacturing for plastics

Joint Working Group between ISO/TC 261 and ISO/TC 61/SC 9 set up to revise.

ISO 27547-1:2010 — Plastics — Preparation of test specimens of thermoplastic materials using mouldless technologies — Part 1: General principles, and laser sintering of test specimens

The below list are standardization activities that ISO/TC 261 Additive manufacturing and ASTM F42 are involved in and may be of interest:

- Non-destructive testing and evaluation — Standard guideline for intentionally seeding flaws in parts;
- Round Robin Testing — Guidance for conducting Round Robin studies;
- Data formats — File format support, ecosystem and evolutions; and
- Test method of sand mold for metal casting — Part 1: Mechanical properties & — Part 2: Physical properties.

As well as a series of standards on the qualification of machine operators for DED-ARC, DED-LB, PBF-EB and PBF-LB.

For the full list of standards under development view the following Link.

▪ Augmented Reality (AR)

Augmented reality (AR) provides workers with real-time information to improve decision making and work procedures thus supporting the production processes. AR is a technologically enhanced version of reality created by using technology to overlay digital information on an image of something being viewed through a device, such as smart goggles or a smartphone camera. The goggles are often voice-controlled, leaving wearers with both hands free.

In manufacturing, looking at a piece of equipment through an AR device could show important data related to the machine, such as its current performance, output, temperature. The most beneficial area of AR's use is to help solve problems related to maintenance. For instance, if a piece of manufacturing equipment is broken, a technician could use a mixed-reality headset to simultaneously examine the physical parts of the machine while also viewing text, instructions and images to help fix the problem. The information that technicians need when checking or repairing an industrial motor can be projected directly onto the part on which they are operating. This eliminates the need to consult charts and instruction manuals, speeding up the process[37].

AR devices can also be used for training new staff, an AR device could automatically provide machine data to help the employee complete the task correctly and safely, delivering alerts if the machine is outside the specified temperature range. It can also ensure that employees are aware of the correct protocols and procedures.

ISO/IEC/JTC1/SC 24 Computer graphics, image processing and environmental data representation

The committee delivered a series of standards: ISO/IEC 14478 series on the virtual reality modeling language, presentation environment for multimedia objects, ISO/IEC 12087 series on Image processing, ISO/IEC 9636 series on the exchange interfacing techniques for dialogues with graphical devices and ISO/IEC 9593 series on the programmer's hierarchical interactive graphics system. In 2019 ISO/IEC 18039:2019 on mixed and augmented reality (MAR) reference model, ISO/IEC 18040:2019 on live actor and entity representation in mixed and augmented reality (MAR), ISO/IEC 18520:2019 for benchmarking of vision-based spatial registration and tracking methods for mixed and augmented reality (MAR), and ISO/IEC 19774-1:2019 and part 2 on Humanoid animation were all published. In 2020 ISO/IEC 18038:2020 for sensor representation in mixed and augmented reality was made available.

The below list are standardization activities that ISO/IEC/JTC1/SC 24 are involved in and may be of interest:

- Information model for mixed and augmented reality: — Part 2: Augmentation Style Specification;
- Computer graphics, image processing and environmental data representation — Environmental Data Coding Specification (EDCS) language bindings — Part 5: C++;
- Computer graphics, image processing and environmental data representation — Material Property and Parameter Representation for Model based Haptic Simulation of Objects in Virtual, Mixed and Augmented Reality (VR, MAR);
- Computer graphics, image processing and environmental data representation — Display device interface for mixed and augmented reality; and
- Computer graphics, image processing and environmental data representation — Material Property and Parameter Representation for Model based Haptic Simulation of Objects in Virtual, Mixed and Augmented Reality (VR, MAR).

For the full list of standards under development view the following Link.

[37] https://www.reliableplant.com/Read/31709/ar-improve-manufacturing

ISO/IEC/JTC1/SC 29 Coding of audio, picture, multimedia and hypermedia information

ISO/IEC JTC 1/SC 29 standards can be used for transmission of VR AR data[38]. Published in 2017 ISO/IEC 23000-13:2017 *Information technology - Multimedia application format (MPEG-A) — Part 13: Augmented reality application format* which includes scene description elements for representing AR content. SC 29 published standards: ISO/IEC 10918 series on digital compression and coding of continuous-tone still images, ISO/IEC 11172 series on the coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s, ISO/IEC 14496 series on the coding of audio visual objects.

In 2019 the following were released: ISO/IEC 21122:2019 part 1 to part 5 on JPEG XS low-latency lightweight image coding system series, ISO/IEC 23001:2019 part 13 till part 15 on MPEG system technologies, and ISO/IEC 23005:2019 part 5 to part 7 on media context control.

In 2020 among other standards the following were released: ISO/IEC 14496- 14:2020 on MP4 file format, ISO/IEC 15938-6:2020 on reference software, ISO/IEC 18477-1:2020 on core coding system specification and ISO/IEC 19566-4:2020 on privacy and security with jpeg systems

Through the collective efforts of industry and academia, ISO/IEC/JTC1/SC 29 (Coding of audio, picture, multimedia and hypermedia information) has made invaluable contributions to a diverse range of applications, both creative and technical. The committee has published over 578 ISO standards with around 90 more currently under development, some of which have even been recognized by the Television Academy Emmy Awards for their technical and engineering excellence. Now with a new Working Group and Advisory Group structure, reflecting the committee's relevance across a multiplicity of industries, SC 29 continues to play an instrumental role in emerging technologies, including Augmented Reality. For many years, SC 29's work in progressing the standardization of scene description and media compression has laid much of the groundwork for immersive technologies coming to fruition today. The protocols associated with media scene description and integrated media compression form part of the published standard ISO/IEC 23000-13:2017 (Information technology - Multimedia application format (MPEG-A) - Part 13: Augmented reality application format). Furthermore, SC 29 collaborates with ISO/IEC JTC 1/SC 24 (Computer graphics, image processing and environmental data representation) on MPEG-MAR – a Mixed and Augmented Reality Reference Model.

For the full list of standards under development view the following Link.

[38] https://www.iso.org/files/live/sites/isoorg/files/developing_standards/who_develops_standards/docs/White_Paper_VRAR.pdf

▪ Simulation

Simulation mirrors the physical world to test and optimize processes and products. For instance, a digital twin is a virtual representation of a physical object across its lifecycle. It uses real-time data from IoT sensors to monitor the machines temperature, output and other KPI's to create a virtual Model. This model provides a better understanding of the machine and its capabilities by enabling virtual testing.

The digital twin can allow companies to have a complete digital footprint of their products from design and development through the end of the product life cycle. With the creation of the digital twin, companies may realize significant value in the areas of speed to market with a new product, improved operations, reduced defects, and emerging new business models to drive revenue. The digital twin may enable companies to solve physical issues faster by detecting them sooner, predict outcomes to a much higher degree of accuracy, design and build better products, and, ultimately, better serve their customers. With this type of smart architecture design, companies may realize value and benefits iteratively and faster than ever before[39]. Listed below are four keyways smart manufacturers will leverage digital twins to achieve a product-centric and model-based enterprise[40].

1. *Engineering*

Traditionally, engineering has used digital twins to create virtual representations for designing and enhancing products. In this application, the digital twin actually exists before its physical counterpart does, essentially starting out as a vision of what the product should be. IoT innovations now make it possible to capture data from products deployed into the field. This data can be applied to the digital twin for continuous product improvement.

2. *Design customization*

As consumers continue to demand customized products, digital twins will allow design and engineering to model the various permutations. Previously, manufacturers have struggled with the best way to incorporate customer input into the manufacturing process. digital twins will make it easier to meet customer demands and integrate usage data that will enhance customization options.

3. *Production*

Digital twins will make it possible for manufacturers to achieve a “single version” of the truth. Ideally, manufacturers will have a single set of digital twin master data that resides in a central location. That will give manufacturers one version of the truth. When combined with “in-memory” computing-based networks plus a lightweight, change-controlled model capability, manufacturers will be able to analyze and visualize data rapidly. The digital twins can also be used to compare quality data across multiple products. This provides deeper insight into global quality issues and allows manufacturers to quickly visualize issues against the “single source truth” model.

4. *Operations*

Operations enhancement is one of the best-understood applications for digital twins. Manufacturers first create a virtual representation of an asset in the field using lightweight model visualization. Next, manufacturers capture data from smart sensors embedded in the asset, providing a clearer picture of real-world performance and operating conditions. Manufacturers can also simulate that real-world environment for predictive maintenance.

For example, let’s say your business manufactures wind turbines. Your company can capture data on rotor speed, wind speed, operating temperature, ambient temperature, humidity, and other metrics to understand and predict product performance. This allows your business to schedule maintenance before a crucial part breaks, thereby optimizing uptime and minimizing repair costs.

ISO/TC 184/SC 4 Industrial Data

In almost every interaction you have with the physical world, a virtual representation of that experience was created somewhere, by someone in order to provide you with the richest experience possible. Industrial Data exists in every aspect of society. From the earliest ideas about how to make the world better, to the concept phase where many ideas are evaluated to the design and manufacturing of real products and services through the support cycle and finally reclamation and recycling in a circular economy, Industrial Data allows computers to create a digital representation of these experiences.

ISO/TC 184/SC4 generated a series of standards dealing concerning data quality, frameworks and exchange of data such as in ISO 8000 series and ISO 10303 series.

[39] https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/cip/deloitte-cn-cip-industry-4-0-digital-twin-technology-en-171215.pdf
[40] https://www.digitalistmag.com/digital-supply-networks/2018/04/04/use-digital-twins-to-disrupt-manufacturing-06042224/

The below list are standardization activities that ISO/TC 184/SC4 are involved in and may be of interest:

- Data quality — Part 117: Application of ISO 8000-115 to Quality Blockchains;
- Industrial automation systems and integration — Product data representation and exchange;
- Industrial automation systems and integration — COLLADA digital asset schema specification for 3D visualization of industrial data; and
- Automation systems and integration — Digital Twin framework for manufacturing.

For the full list of standards under development view the following Link.

Digital Twin

At the November 2020 JTC 1 Plenary two new work items have been approved, covering Terminology and definitions, and Use cases. These work items have been allocated to JTC 1 subcommittee (SC) 41 Internet of Things and digital twin, to be developed into international standards. Currently JTC1/SC 42/WG 4 "Use cases and applications" can contribute to Use Cases that also cover digital twin topics.

Reference Architecture Model

Germany uses the RAMI 4.0 Reference Architecture Model, which is a three-dimensional map showing how to approach the deployment of Industry 4.0 in a structured manner. The central concept of Industry 4.0 is that assets can be combined in any way, and these assets are formally described in sufficient detail for use in the digital world. This methodology not only enables sufficient generic descriptions of a configuration, but through an increasing degree of detail also allows for very specific descriptions. This is a core concept of RAMI4.0 regardless of the way in which the asset is used. IEC PAS 63088:2017 — Smart manufacturing – Reference architecture model industry 4.0 (RAMI4.0) describes a reference architecture model in more detail[41].

Asset Administration Shell

RAMI 4.0 Reference Architecture Model is used as a basis for developing the building blocks that are required for the implementation of the Asset Administration Shell (AAS) and the specifications and rules governing the interaction between the I4.0 components. The AAS, a key concept of Industry 4.0 (or “Industrie 4.0” in German), is used to describe an asset electronically in a standardized manner. Its purpose is to exchange asset-related data among industrial assets and between assets and production orchestration systems or engineering tools. The AAS consists of several sub-models in which all the information and functionalities of a given asset are stored – including its features, characteristics, properties, status, parameters, measurement data and capabilities – all of which are described. It allows for the use of different communication channels and applications and serves as the link between I4.0 objects and the connected, digital and distributed world. AAS is another word for the digital twin.

The European Factories of the Future Research Association

The European Factories of the Future Research Association (EFFRA) is a non-for-profit, industry-driven association promoting the development of new and innovative production technologies. It is the official representative of the private side in the 'Factories of the Future' public-private partnership. The key objective of EFFRA is to promote pre-competitive research on production technologies within the European Research Area by engaging in a public-private partnership with the European Union called 'Factories of the Future'. They have developed a Wiki where you can view their current projects and find useful information with regards standards and standardization[42].

[41] IEC PAS 63088:2017 — Smart manufacturing – Reference architecture model industry 4.0 (RAMI4.0)
[42] https://www.effra.eu/factories-future

▪ Blockchain

Blockchain is a shared ledger that is designed to be tamper-resistant and to create definitive and immutable records. It is attractive to many industries and governments as it records transactions in a transparent and secure way, thus increasing trust, limiting intermediaries and reducing costs. There is digital information (the block) stored on a database (the chain). When new information is stored a block is added to the blockchain.

Blockchain-powered solutions can accumulate all of the information needed to deliver significant value for industrial companies and help unlock the full potential of other advanced manufacturing technologies, such as augmented reality, IoT and 3D printing. As Blockchains can increase transparency throughout supply chains, track the identity and credentials of key personnel and allow for more seamless audit and compliance functionality[43].

There is great potential for blockchain in manufacturing. Increasing visibility across all areas of the process from suppliers, strategic sourcing, procurement and supplier quality to shop floor operations which include machine-level monitoring and service, blockchain can allow for an entirely new manufacturing business model. Supply chains are the basis of all manufacturing businesses, most of which are capable of making use of blockchain's distributed ledger structure and block-based approach to aggregating value-exchange transactions to improve efficiency. By scaling supplier order accuracy, product quality and track-and-traceability, manufacturers will be able to better hit delivery dates, enhance product quality and ultimately sell more. Blockchain can significantly influence manufacturing by:

- Enhancing track and trace;
- Protecting and monetising critical intellectual property;
- Simplifying and safeguarding quality checks;
- Advancing machines as a service; and
- Enabling machine-controlled maintenance.

Blockchain in Ireland

Origin Chain Networks OCN's involvement with European technology standards development has influenced the adoption of a farmer-first data ownership model. This model has its origins in self-sovereign identity management practices found in blockchain and distributed ledger technology (DLT) and extends the model to include role-based farm data digitisation. The use case describes a blockchain-enabled platform available to farmers and agri-compliance bodies, facilitating rapid and near real-time data-sharing. Universal Farm Compliance helps farmers and the entire agri-food ecosystem to implement a safer, more transparent food supply chain, and advances digital transformation in the agri-food industry. OCN were awarded with a Standards + Innovation Contributor award 2020 for their involvement in standardization in the field of interoperable blockchain infrastructure.

Aldi is the first retailer in Ireland to test blockchain technology successfully to validate its corporate buying policy for organic and sustainably produced Irish seafood. Aldi and Verifish are participating in a pilot project with Bord Iascaigh Mhara (BIM), Ireland's seafood development agency. This project is funded under the European Maritime and Fisheries Fund. Developed by Verifish and supported by BIM, the pilot blockchain project captures all information from catch through to the retail shelves. The goal of the project is to increase visibility in the supply chain bringing assurance to consumers. This will add to Aldi's strong sustainability credentials. Following the completion of the first phase of the pilot programme, Aldi has introduced the system to its Irish Organic Salmon and its Wild Irish Hake products. Following the programme, which runs for 12 months in two phases, Aldi aims to introduce the blockchain traceability system across its entire Irish-sourced white fish ranges by early 2021[44].

The Department of Finance will establish A Fintech Foresight Group of public and private stakeholders, to drive the development of fintech using blockchain and other technologies under the "Ireland for Finance" 2025 strategy. Action 29 from the strategy establishes that the Department of Finance will integrate new technologies such as blockchain, this measure involves the IFS sector delivering DLT and blockchain initiatives to demonstrate Ireland's credentials as an EU centre of excellence for distributed ledger technology by going live with MMIF returns through DLT and applying natural language processing and workflow using the Disruptive Technologies Innovation Fund.

[43] https://www.manufacturingglobal.com/smart-manufacturing/role-blockchain-manufacturing
[44] https://veri.fish/verifish-blockchain-technology-goes-live-with-aldi/

ISO/TC 307 - Blockchain and distributed ledger technologies

In 2019 ISO/TR 23455:2019, *Blockchain and distributed ledger technologies – Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems.* It provides an overview of smart contracts, describing what these are, how they work and methods of interaction between them.

In 2020 the recently published ISO 22739:2020, *Blockchain and distributed ledger technologies – Vocabulary*, helps to resolve this issue by defining the basic terms relating to blockchain and distributed ledger technologies and providing a common language that can be used worldwide. While the newly published technical report ISO/TR 23244:2020, *Blockchain and distributed ledger technologies – Privacy and personally identifiable information protection considerations*, identifies and assesses known privacy-related risks and offers ways to mitigate them. It also covers the privacy-enhancing potential of blockchain and DLT. ISO/TR 23455:2019, *Blockchain and distributed ledger technologies – Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems.* It provides an overview of smart contracts, describing what these are, how they work and methods of interaction between them. ISO/TR 23576:2020, *Blockchain and distributed ledger technologies — Security management of digital asset custodians,* illustrates the security risks, threats, and measures which digital asset custodians consider, design, and implement in order to protect the assets of their customers, based on best practices, existing standards and research.

The below list are standardization activities that ISO/TC 307 are involved in and may be of interest:

- Use cases;
- Identifiers of subjects and objects for the design of blockchain systems;
- Data flow model for blockchain and DLT use cases;
- Vocabulary;
- Overview of existing DLT systems for identity management;
- Reference architecture;
- Taxonomy and Ontology;
- Legally binding smart contracts;
- Guidelines for governance;
- Overview of smart contract security good practice and issues; and
- Overview of trust anchors for DLT-based identity management (TADIM).

For the full list of standards under development view the following Link.

▪ The Industrial Internet of Things (IIoT)

IIoT refers to the connection of devices and objects to the Internet's network of networks using sensors combined with big data analytics and cloud computing. The key concept of the IIoT is thus to integrate machine learning and big data technologies and thus considerably increase the effectiveness of companies.

Given the increasing adoption of IIoT by manufacturers it is enabling end-to-end visibility of their industrial operations and the monitoring of key efficiency metrics. These might include monitoring of machines (asset downtime, changeover times), the factory (overall equipment effectiveness, product throughput) and other valuable insights such as quality monitoring[45].

In the IIoT, the combination of sensors and analytics allows real-time access to data that was previously unavailable. The findings from this data are fed into the processes along the entire supply chain without delay. IIoT creates many possibilities for the manufacturing industry[46]:

- Optimization of processes (e.g. through remote monitoring);
- Greater flexibility of production processes;
- Increasing degree of automation;
- Increased operational efficiency and lower failure rates;
- Faster detection of productivity weaknesses and problems;
- More accurate predictions of machine condition and more efficient maintenance;
- Cost savings by avoiding unnecessary repairs;
- Better availability and fewer machine failures;
- Improved quality control and reduction of the error rate;
- Improved transparency through worldwide access to machine data;
- Improved technical customer service; and
- Development of trend-setting business areas and models (e.g. supplementary services such as remote troubleshooting or predictive maintenance).

Today, there are a number of standards available that must be considered together, in an integrated fashion, to facilitate the transformative business opportunities of smart manufacturing: I.S. EN ISO/IEC 27000:2017 on information security, ISO 28000:2007 on supply chain security, and I.S. EN IEC 62443 series on industrial control systems and automation. Existing standards need to be amended to fully enable advanced industrial technologies to develop, especially in cyber-physical security, cloud-based manufacturing services, supply chain integration and data analytics[47].

ISO/IEC JTC1/SC 41 Internet of things and related technologies

This committee produced a series of standards ISO/IEC 29182 series relating to Sensor Network Reference Architecture (SNRA), ISO/IEC 20924:2018 on vocabulary, ISO/IEC TR 22417:2017 on use cases, along with ISO/IEC 30141:2018 on reference architecture.

In 2020 ISO/IEC TR 30166:2020 for IIoT, ISO/IEC TR 30164:2020 for edge computing and ISO/IEC 30142:2020 for Underwater acoustic sensor network (UWASN) were made available. At the November 2020 Plenary of JTC 1 two new work items were proposed for the digital twin, Use Cases and concepts & terminology.

The below list are standardization activities that ISO/IEC JTC1/SC 41 are involved in and may be of interest:

- Methodology for trustworthiness of IoT system/service;
- Trustworthiness framework;
- Compatibility requirements and model for devices within industrial IoT systems;
- Real-time IoT framework;
- Digital Twin — Use cases; and
- Digital Twin — Concepts and terminology.

For the full list of standards under development view the following Link.

[45] The State of Industrial Internet of Things 2019:Spotlight on Operational Effectiveness 2019 by PTC
[46] https://www.lead-innovation.com/english-blog/industrial-internet-of-things
[47] https://www.iso.org/news/2016/09/Ref2115.html

▪ Cybersecurity

Cybersecurity is required due to the increased cyber threats from the integration of manufacturing and production into data-driven systems. This is recognized in the creation of the he EU Cybersecurity Act. This introduces for the first time an EU-wide cybersecurity certification framework for ICT products, services and processes. Companies doing business in the EU will benefit from having to certify their ICT products, processes and services only once and see their certificates recognized across the European Union. Furthermore, the National Cyber Security Strategy refers to government departments being in line with international best practices through standards like ISO 27001:2017.

Industry 4.0, is taking off as factories start to take advantage of data analytics and related technologies. This technological transformation brings some new concerns as well, as the industry becomes more data-driven and connected manufacturers must consider cybersecurity for not only their data and network. They must also consider cybersecurity of their IIoT devices from robots, routers, servers, laptops etc. Assessing the vulnerabilities and the effect a cyber attack may have on the safety functionality of the robot, the operating parameters etc. Standards are trying to address this issue in the following:

- ISO/DIS 10218-1 sets out safety requirement for robot systems for the robot, in the current revision making it a requirement to carry out a cybersecurity assessment of the robot;
- ISO/DIS 10218-2 sets out safety requirement for robot systems, robot application and robot cells integration. Part 2 goes further making cybersecurity measures a requirement to prevent unauthorized access to the control system, where the assessment identified that a threat could result in (safety) risk(s);
- I.S. EN IEC 61508 covers safety-related systems that incorporate electrical / electronic / programmable electronic devices and addresses cybersecurity in an informative way. It requires that malevolent and unauthorized actions have to be considered during hazard and risk analysis. Cyber requirements need to be specified once the cybersecurity vulnerability and threat analyses are conducted. Security threat analysis and vulnerability analysis should be carried out if a hazard analysis identifies a malicious or unauthorized cyber event as being reasonably foreseeable;
- I.S. EN IEC 62443 refers to a series of international standards on "Industrial communication networks - IT security for networks and systems". This is divided into different sections and describes both technical and process-related aspects of industrial cybersecurity. It divides the industry into different roles such as: the operator, the integrators (service providers for integration and maintenance) and the manufacturers; and
- ISO/IEC 30141 is a reference architecture standard for the internet of things (IoT). It makes reference that monitoring and analyzing deployed IoT systems is essential to maintain reliability and safety and security. Ubiquitous penetration of IoT into virtually all areas of life increases the attack surface, multiplying the number of potential attack targets and often rendering measures such as physical security controls ineffective. It highlights the need for information security as well as security in areas such as network connectivity, auto configuration, Network management, IoT gateway.

ISO/IEC JTC1/SC 27 Information security, cybersecurity and privacy protection

Developed ISO/IEC 18033 series standards around encryption algorithms, ISO/IEC 20009 series anonymous entity authentication and ISO/IEC 19989 series criteria and methodology for security evaluation of biometric systems. In 2020 ISO/IEC 20547 series on big data reference architecture was published along with ISO/IEC 20085-2:2020 for test calibration methods and apparatus in testing noninvasive attacks authenticated encryption, ISO/IEC 19772:2020 on authenticated encryption and ISO/IEC 27007:2020 providing guidelines for information security management systems auditing.

The below list are standardization activities that the committee are involved in and may be of interest:

- Organizational privacy risk management;
- User-centric framework for the handling of personally, identifiable information (PII) based on privacy preferences;
- IoT security and privacy — Guidelines; and
- IoT security and privacy — Device baseline requirements.

For the full list of standards under development view the following Link.

▪ Cloud Computing & Big Data

Cloud Computing allows the storage of large amounts of data. This capacity is mainly important to store the data generated during a whole production process, considering that the machines and sensors produce more data than a person and such data is always connected. Likewise, cloud computing reduces investment in technological resources, allowing the storage space and processing capacity to be contracted on demand, which provides flexibility, agility, and adaptability. Making cloud computing a technology enabler for Industry 4.0.

Big Data techniques allow the analysis of enormous volume of information that is generated in an Industry 4.0 production ecosystem. Techniques such as advanced, historical, predictive and descriptive analysis enables to assess the state and operation of the machines involved in production processes, control and monitoring. The analysis of data for predictive maintenance reduces inefficiencies and costs, anticipating equipment failures and allowing better responses to emergent and remote situations caused by different factors such as bad weather, high humidity, high temperature, exposure to gases, etc.

The high degree of interconnection of Industry 4.0 requires standards to facilitate its implementation. For this reason, it is necessary to deepen the study of existing standards currently on cloud computing and big data to identify which should be adapted and which should be defined so to ensure interoperability and complementarity[48].

ISO/IEC JTC1/SC 38 Cloud Computing and Distributed Platforms

Published ISO/IEC 18384 series of standards relating to reference Architecture for Service Oriented Architecture (SOA RA) and ISO/IEC 19086 series relating to cloud computing. In 2020 the following were published: ISO/IEC TS 23167:2020 common technologies and techniques, as well as a number of technical reports; ISO/ IEC TR 23187:2020 on interacting with cloud service partners, ISO/IEC TR 23188:2020 on the edge computing landscape, ISO/IEC TR 23613:2020 on cloud service metering elements and billing modes and ISO/IEC TR 23951:2020 for guidance for using the cloud SLA metric model.

The below list are standardization activities that ISO/IEC JTC1/SC 38 are involved in and may be of interest:

- Audit of cloud services;
- Concepts for multi — cloud and other interoperation of multiple cloud services;
- Cloud computing and distributed platforms — Data flow, data categories and data use — Part 2: Guidance on application and extensibility; and
- Cloud computing and distributed platforms — Data sharing agreement (DSA) framework.

For the full list of standards under development view the following Link.

Furthermore, a new series of standards are being developed: ISO/IEC FDIS 22123-1- Part 1: Vocabulary and ISO/IEC CD 22123-2.2 – Part 2: Concepts.

[48] https://www.researchgate.net/publication/329594852

ISO/IEC JTC1/SC 42/WG 02 Data

The JTC 1 big data programme was transferred under SC 42 and has two foundational projects for the overview and vocabulary and a big data reference architecture (BDRA). In addition, it has initiated work looking at the business process management for big data analytics. It has published the following standards:

- ISO/IEC 20546:2019: — Information technology — Big data — Overview and vocabulary;
- ISO/IEC 20547-1:2020: — Information technology — Big data reference architecture — Part 1: Framework and application process; and
- ISO/IEC 20547-3:2020: — Information technology — Big data reference architecture — Part 3: Reference architecture.

The below list are standardization activities that ISO/IEC JTC1/SC 42/WG 02 are involved in and may be of interest:

- Overview, terminology, and examples;
- Data quality measures;
- Data quality management requirements and guidelines;
- Data quality process framework; and
- Artificial intelligence — Process management framework for Big data analytics.

For the full list of standards under development view the following Link.

▪ **Artificial intelligence (AI)**

Data has become a highly valuable resource, and it's cheaper than ever to capture and store. Today, more manufacturers than ever are leveraging that data to significantly improve their bottom line thanks to Artificial Intelligence. The major use cases of Machine Learning in manufacturing are outlined below:

- **Predictive maintenance:** by preempting a failure with a machine learning algorithm, systems can continue to function without unnecessary interruptions. When maintenance is needed, it's very focused and technicians are informed of the components that need inspection, repair and replacement, which tools to use, and which methods to follow.
  Predictive maintenance also leads to a longer Remaining Useful Life (RUL) of machinery and equipment since secondary damage is prevented while smaller labour forces are needed to perform maintenance procedures;
- **Predictive quality and yield:** automatically identifies the root causes of process-driven production losses using continuous, multivariate analysis, powered by Machine Learning algorithms that are uniquely trained to intimately understand each individual production process. Automated recommendations and alerts can then be generated to inform production teams and process engineers of an imminent problem, and seamlessly share important knowledge on how to prevent the losses before they happen. Reducing these types of losses has always been a struggle for manufacturers[49];
- **Making use of data:** via supply chain management, risk management, predictions on sales volume, product quality maintenance, prediction of recall issues. These are just some of the examples of how big data can be used to the benefit of manufacturers. This type of AI application can unlock insights that were previously unreachable;
- **Generative design:** is a process that involves a program generating a number of outputs to meet specified criteria. Designers or engineers input design goals and parameters such as materials, manufacturing methods, and cost constraints into generative design software to explore design alternatives. The solution utilizes machine learning techniques to learn from each iteration what works and what doesn't[50];
- **The customer experience:** chatbots can interpret what a customer is looking for, passing over more complex problems and questions to one of your employees when needed. Chatbots also means fewer errors when dealing with your customers by using intuitive technology to interpret customer needs and responses. They can also navigate the website and provide the customer will all the relevant information they might need;
- **Environmental impact:** AI could help to transform manufacturing by reducing, or even reversing, its environmental impact. AI can support developing new eco-friendly materials and help optimize energy efficiency. Google already uses AI to do that in its data centers;
- **Price forecasting of raw materials:** the extreme price volatility of raw materials has always been a challenge for manufacturers. Businesses have to adapt to the unstable price of raw materials to remain competitive in the market. AI powered software can predict materials prices more accurately than humans and it learn from its mistakes;
- **Inventory management:** machine learning solutions can promote inventory planning activities as they are good at dealing with demand forecasting and supply planning; and
- **Cost reduction:** leveraging AI technologies can enhance organizations' analytics capability so that they can use their resources more efficiently, make better forecasts, reduce inventory costs.

[49] https://www.seebo.com/machine-learning-ai-manufacturing/
[50] https://neoteric.eu/blog/10-use-cases-of-ai-in-manufacturing/

ISO/IEC/JTC1/SC 42 Artificial intelligence

Subcommittee SC 42, which is under joint technical committee JTC 1 of ISO and the International Electrotechnical Commission (IEC), is the only body looking at the entire AI ecosystem. The AI ecosystem has been divided into a number of key areas spanning technical, societal and ethical considerations. These include the following broad categories:

- Foundational standards;
- Computational ,methods & techniques;
- Trustworthiness;
- Use cases & applications;
- Societal concerns;
- Big Data; and
- Exponential growth.

SC 42 has published ISO/IEC Technical Report 20547 part 1 to 5, which provides a framework and application process for organizations to apply to build a big data architecture for their problem domain. ISO/IEC TR 24028:2020 gives an overview of trustworthiness in artificial intelligence and was published in 2020. These standards aim to ensure interoperability and facilitate the uptake in the use of Machine Learning Algorithms that will transform the manufacturing ecosystem. For example, the Use Cases being developed by SC 42 will provide guidance and direction with regards to the use of digital twin.

ISO/IEC TR 24028:2020, — *Information technology – Artificial intelligence – Overview of trustworthiness in artificial intelligence*, analyses the factors that can impact the trustworthiness of systems providing or using AI. Trustworthy AI systems must be fair, safe and accountable. They must respect individual privacy, must not discriminate and should be transparent and accountable. ISO/IEC TR 24028 examines the existing approaches that can support or improve trustworthiness in technical systems and discusses their potential application to AI. It also discusses possible approaches to mitigating AI system vulnerabilities and ways to improving their trustworthiness.

The below list are standardization activities that ISO/IEC JTC1/SC 42 are involved in and may be of interest:

- Assessment of machine learning classification performance;
- Overview, terminology and examples;
- Data quality measures;
- Data quality management requirements and guidelines;
- Guidelines for AI applications;
- Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML);
- Risk Management;
- Bias in AI systems and AI aided decision making;
- Assessment of the robustness of neural networks — Part 1: Overview;
- Assessment of the robustness of neural networks — Part 2: Methodology for the use of formal methods;
- Use cases;
- Overview of ethical and societal concerns;
- Process management framework for Big data analytics;
- Governance implications of the use of artificial intelligence by organizations; and
- Management system.

For the full list of standards under development view the following Link.

▪ Nanotechnology

In the field of nanotechnology new properties are being imparted to materials, making them stronger, lighter, or more electrically conductive. Nano is any material made up of at least 50% of particles between one and 100 nanometers in size or, about one-hundredth to one-tenth the size of the average germ.

Nanotechnology has grown rapidly over the past few years. There are a few reasons for the sudden growth. Working at microscopic scales allows you to, for example, create ultra-thin and flexible circuit boards. Plus, there are unique advantages that only nanomaterials can offer. The uses of Nanomaterial used in manufacturing are listed below[51]:

- Carbon nanotubes are some of the most widely used nanomaterials, simply due to the material's set of unique characteristics. They are already being used in situations where a manufacturer needs high wear resistance and break strength at a light weight — for example, bike frames, bulletproof vests, industrial robot arms, sailboat hulls and spaceship components, among others;
- Carbon nanofibers are sometimes used in the manufacture of safety wear, especially bio textiles, where they can provide several highly useful qualities — like liquid and stain resistance, as well as antimicrobial properties; and
- Carbon nanoparticles can also be used in combination with heavy, non-nano materials, like steel. When distributed throughout steel, these nanoparticles can increase its strength. They can ultimately reduce the amount of material needed, creating lighter weight objects without depending entirely on nanomaterials.

Popular nanomaterials, like carbon nanotubes, are already widely fabricated and applied in the manufacture of a variety of goods, including sailboat hulls, bicycle frames and spaceship components. In electronics, design at the nanoscale is creating highly flexible devices and circuit boards. Nanotech and manufacturing are linking in ways that will inform future processes as outlined below:

- Nanotechnology can also be used to create more effective and stable lubricants, which are useful in a variety of industrial applications. At the nanoscale, materials can act similarly to ball-bearings in petroleum-based lubricants, keeping things flowing smoothly, ensuring even distribution and limiting aggregation. They can make sure machine components stay lubricated, even in the face of rapid changes in temperature or pressure; and
- Nanotechnology is also used in car manufacturing. Tire manufacturers are increasingly using polymer nanocomposites in high-end tires to increase their durability and wear resistance. In addition, nanotech can be applied in the manufacture of improved consumer car products, like motor oil.

ISO TC 229 Nanotechnology

Developed ISO/TS 80004 series for vocabulary along with standards for measurement of particle size, analysis of nano objects and materials specifications. In 2020 ISO 17200:2020 on nanoparticles in powder and ISO/TS 21975:2020 on Polymeric nanocomposite films for food packaging with barrier properties were produced.

The below list are standardization activities that ISO/TC 229 are involved in and may be of interest:

- Characterization of carbon nanotube and carbon nanofiber aerosols in relation to inhalation toxicity tests;
- Multiwall carbon nanotubes — Determination of amorphous carbon content by thermogravimetric analysis;
- A guideline for ellipsometry application to evaluate the thickness of nanoscale films; and
- Core terms and definitions.

For the full list of standards under development view the following Link.

[51] https://www.manufacturingtomorrow.com/article/2020/03/nanotechnology-in-manufacturing/14945

STANARDIZATION LANDSCAPE

NSAI

There are a number of National Mirror Committees outlined below and in Table 1, that are following and/or participating in the standardization of Industry 4.0 enabling technologies, following the development of International Standards at an ISO level as well as European standards at the CEN level. A traffic light system is used to highlight the relevant committees. These are areas where NSAI provides an opportunity to Irish experts to voice Ireland's national position and influence international standards. NSAI aims to inform Irish industry of the standards that support the existing and emerging technologies that make up Industry 4.0.

The colour coding in Table 1 highlights the activity areas in the Irish National Mirror Committees. Green signifies a high national engagement, orange signifies medium national engagement, and red signifies low national engagement. The traffic light system beside each committee corresponds to Table 1.

COMMITTEE REFERENCE	COMMITTEE NAME	ACTIVITY
NSAI/TC 2/SC 03/WG 01	Coding of moving pictures and audio	High
NSAI/TC 2/SC 09	Automatic Identification and Data capture Techniques	Low
NSAI/TC 2/SC 10	IT Security Techniques	High
NSAI/TC 2/SC 11	Cloud Computing and Distributed Platforms	Medium
NSAI/TC 2/SC16	Blockchain and electronic distributed ledger technologies	High
NSAI/TC 2/SC 18	Artificial Intelligence	High
NSAI/TC 23/SC 05/WG 01	Ergonomics	Low
NSAI/TC 47/SC 38	Ergonomics	Low
NSAI/TC 48/SC 10	Safety of Machinery	Medium
NSAI/TC 48/SC 11	Automation Systems and Integration	Low
NSAI/TC 48/SC 22	Applications of statistical methods	Low
NSAI/TC 49/SC 01	Nanotechnologies	Medium
NSAI/TC 49/SC 02	Additive Manufacturing	High
NSAI/TC 49/SC 03	Robotics	High
NSAI/TC 59	Energy Management & Energy Savings	High

Table 1: NSAI National Mirror Committees

NSAI/TC 2/SC 03/WG 01	Coding of moving pictures and audio	TC	Membership 16

Scope

Standardization in the field of:

- Efficient coding of digital representations of images, audio and moving pictures, including:
  - Conventional (natural, computer-generated and immersive) images, moving pictures and audio;
  - Invisible light and other sensory (such as medical and satellite) images; and
  - Static and dynamic graphic objects.
- Efficient coding of other digital information, including:
  - Multimedia, environment and user related metadata;
  - Sensor and actuator information related to audio-visual information; and
  - Other digital data in agreement with the relevant committee, such as genomics.
- Digital information support, including:
  - Synchronization, presentation, storage and transport of single or combinations of media;
  - Media security and privacy management; and
  - Quality of experience evaluation and system performance metrics.

The national committee will participate in the development of international standards at an ISO level. This committee will not produce indigenous Irish standards.

Following	ISO/IEC JTC 1/SC 29

NSAI/TC 2/SC 09	Automatic Identification and Data capture Techniques	TC	Membership 7

Scope

Standardization of data formats, data syntax, data structures, data encoding and technologies for the process of automatic identification and data capture and of associated devices utilized in inter-industry applications and international business interchanges and for mobile applications. The national committee will participate in the development of international standards at an ISO level as well as European standards at the CEN level. This committee will not produce indigenous Irish standards.

Following	CEN/TC 225	ISO/IEC JTC 1/SC 31

NSAI/TC 2/SC 10	IT Security Techniques	TC	Membership 30

Scope

The development of standards for the protection of information and ICT. This includes generic methods, techniques and guidelines to address both security and privacy aspects, such as:

- Security requirements capture methodology;
- Management of information and ICT security; information security management systems, security processes, and security controls and services;
- Cryptographic and other security mechanisms, including but not limited to mechanisms for protecting the accountability, availability, integrity and confidentiality of information;
- Security management support documentation including terminology, guidelines as well as procedures for the registration of security components;
- Security aspects of identity management, biometrics and privacy;
- Conformance assessment, accreditation and auditing requirements in the area of information security management systems; and
- Security evaluation criteria and methodology.

SC 27 engages in active liaison and collaboration with appropriate bodies to ensure the proper development and application of SC 27 standards and technical reports in relevant areas.

The national committee will participate in the development of international standards at an ISO level as well as European standards at the CEN level. This committee will not produce indigenous Irish standards.

Following	CEN/CLC JTC 13	ISO/IEC JTC1/SC 27

NSAI/TC 2/SC 11	Cloud Computing and Distributed Platforms	SC	Membership 15

Scope

Standardization in the area of Internet of Things and related technologies to:

- Serve as the focus and proponent for JTC 1's standardization programme on the Internet of Things and related technologies, including Sensor Networks and Wearables technologies; and
- Provide guidance to JTC 1, IEC, ISO and other entities developing Internet of Things related applications.

The national committee will participate in the development of international standards at an ISO level. This committee will not produce indigenous Irish standards.

Following	ISO/IEC JTC 1/SC 41	ISO/IEC JTC 1/SC 38

NSAI/TC 2/SC 16	Artificial Intelligence	SC	Membership 36

Scope

Standardization in the area of blockchain and distributed ledger technologies

The committee has been set up to meet the growing need for standardization in this area by providing internationally agreed ways of working with it to improve security, privacy and facilitate worldwide use of the technology through better interoperability. This is especially relevant due to the number of SMEs, across various sectors, that are developing blockchain and distributed ledger technologies as a product.

The national committee will participate in the development of international standards at an ISO level. This committee will not produce indigenous Irish standards.

Following	ISO/IEC JTC 1/SC 42

NSAI/TC 2/SC 18	Artificial Intelligence	SC	Membership 36

Scope

Standardization in the area of Artificial Intelligence to:

- Serve as the focus and proponent for JTC 1's standardization program on Artificial Intelligence; and
- Provide guidance to JTC 1, IEC, and ISO committees developing Artificial Intelligence applications.

The national committee will participate in the development of international standards at an ISO level. This committee will not produce indigenous Irish standards.

Following	ISO/IEC JTC 1/SC 42

NSAI/TC 23/SC 05/WG 01	Ergonomics	WG	Membership 4

Scope

Standardization in the field of ergonomics, general ergonomics principles, anthropometry and biomechanics, ergonomics of human system interaction and ergonomics of the physical environment, addressing human characteristics and performance, and methods for specifying, designing and evaluating products, systems, services, environments and facilities.

Excluded:

Standardization of purely technical matters not related to human characteristics and abilities.

The national committee will participate in the development of international standards at an ISO level. This committee will not produce indigenous Irish standards.

Following	ISO/TC 159

NSAI/TC 47/SC 38	Ergonomics	E-Committee	Membership 1

Scope

Standardization in the field of ergonomics principles and requirements for the design of work systems and work environments, including machinery and personal protective equipment, to promote the health, safety and well-being of the human operator and the effectiveness of the work systems:

The national committee will participate in the development of European standards at the CEN level. This committee will not produce indigenous Irish standards.

Following	CEN/TC 122	CEN/CLC/JTC 19

NSAI/TC 48/SC 10	Safety of Machinery	TC	Membership 5
Scope Standardization of basic concepts and general principles for safety of machinery incorporating terminology, methodology, guards and safety devices within the framework of ISO / IEC Guide 51 and in cooperation with other ISO and IEC technical committees. The national committee will participate in the development of international standards at an ISO level as well as European standards at the CEN level. This committee will not produce indigenous Irish standards. **Excluded:** Product safety standards, as defined in ISO / IEC Guide 51, and which are explicitly covered by the work of other ISO or IEC technical committees.			
Following	CEN/TC 114	ISO/TC 199	

NSAI/TC 48/SC 11	Automation Systems and Integration	E-committee	Membership 0
Scope Standardization of the content, meaning, structure, representation and quality management of the information required to define an engineered product and its characteristics at any required level of detail at any part of its lifecycle from conception through disposal, together with the interfaces required to deliver and collect the information necessary to support any business or technical process or service related to that engineered product during its lifecycle. The national committee will participate in the development of international standards at an ISO level. This committee will not produce indigenous Irish standards.			
Following	ISO/TC 184/SC 4		

NSAI/TC 48/SC 22	Applications of statistical methods	E-committee	Membership 2
Scope Standardization of the content, meaning, structure, representation and quality management of the information required to define an engineered product and its characteristics at any required level of detail at any part of its lifecycle from conception through disposal, together with the interfaces required to deliver and collect the information necessary to support any business or technical process or service related to that engineered product during its lifecycle. The national committee will participate in the development of international standards at an ISO level. This committee will not produce indigenous Irish standards.			
Following	ISO/TC 69		

NSAI/TC 49/SC 01	Nanotechnologies	E-committee	Membership 6

Scope

Standardization in the field of nanotechnologies that includes either or both of the following:

- Understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometres in one or more dimensions where the onset of size-dependent phenomena usually enables novel applications; and
- Utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules, and bulk matter, to create improved materials, devices, and systems that exploit these new properties.

Specific tasks include developing standards for: terminology and nomenclature; metrology and instrumentation, including specifications for reference materials; test methodologies; modelling and simulations; and science-based health, safety, and environmental practices.

Following	CEN/TC 352	ISO/TC 229

NSAI/TC 49/SC 02	Additive Manufacturing	TC	Membership 36

Scope

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.

The national committee will participate in the development of international standards at an ISO level as well as European standards at the CEN level. This committee will not produce Irish standards.

Following	CEN/TC 438	ISO/TC 261

NSAI/TC 49/SC 03	Robotics	TC	Membership 24

Scope

Standardization in the field of robotics, excluding toys and military applications.

This Technical Committee is following the work of ISO/TC 299 & ISO/TC 299/WG3. WG3 is developing safety standards and guidance for robotics that are intended for industrial environments, over their lifecycle.

The national committee will participate in the development of international standards at an ISO level as well as European standards at the CEN level. This committee will not produce indigenous Irish standards.

Following	ISO/TC 299	ISO/TC 299/WG 3

<table>
<tr><td>NSAI/TC 59</td><td>Energy Management & Energy Savings</td><td>TC</td><td>Membership 18</td></tr>
<tr><td colspan="4">Scope

Standardization in the field of energy management and energy savings, within the energy transition framework in close coordination with CEN/CENELEC sectorial strategy including, but not limited to, subjects such as:

-Energy management systems;

-Energy audits;

-Energy efficiency and energy performance improvement;

-Energy and savings calculation methodologies; and

-Energy efficiency improvement financing.

The national committee has produced two Irish standards I.S. 393:2005 Energy Management Systems – Requirements with Guidance for Use and I.S. 399:2014 Energy Efficient Design Management. I.S. 399:2014 is currently being reviewed.</td></tr>
</table>

Following	ISO/TC 301	CEN/CLC JTC 14

CEN & CENELEC

CEN (European Committee for Standardization) and CENELEC (European Committee for Electrotechnical Standardization) bring together the national standards agencies of 34 countries. Their network involves business federations, commercial and consumer organizations, environmental groups and other societal stakeholders. More than 60,000 technical experts from industry, research, academia and other backgrounds are directly involved in the work.

Their National Members work together to develop European standards and other deliverables in a large number of sectors to help build the European internal market for goods and services, removing barriers to trade and strengthening Europe's position in the global economy. They also work closely with the European Commission to ensure that standards correspond with any relevant EU legislation.

European commission can ask one of its ESOs to develop a European standard to comply with a legal provision. Such a standard is called a harmonised standard and gives manufacturers and other operators the presumption of legislative conformity. Their use is optional.

The following committees have been highlighted in the Table 2 below for the important standardization work in emerging technologies surrounding Industry 4.0. A traffic light system of Green or Red is used to display if the CEN or CENELEC Committee has a NSAI National Mirror Committee which corresponds to Y/N in the "MIRRORED" column in Table 2. Green/Y represents mirrored, while Red/N currently represents no National Mirror Committee.

COMMITTEE REFERENCE	COMMITTEE NAME	PUBLISHED STANDARDS	MIRRORED
CEN/TC 114	Safety of Machinery	38	Y
CEN/TC 122	Ergonomics	126	Y
CEN/TC 143	Machine Tools Safety	19	N
CEN/TC 225	AIDC Technologies	20	N
CEN/TC 290	Dimensional and Geometrical Product Specification and Verification	121	N
CEN/TC 310	Advanced automation technologies and their applications	6	N
CEN/TC 319	Maintenance	7	N
CEN/TC 352	Nanotechnologies	23	N
CEN/TC 368	Product Identification	1	N
CEN/TC 438	Additive Manufacturing	17	Y
CEN/CLC/JTC 13	Cybersecurity	21	Y
CEN/CLC/JTC 14	Energy management and energy efficiency in the framework of energy transition	9	Y
CEN/CLC/JTC 19	Blockchain and Distributed Ledger Technologies	NA	Y
CEN/CLC/BT/WG 06	ICT Standardization Policy	NA	NA
CENELEC/TC 65X	Industrial Automation	455	N
CEN/CLC/ETSI SMa-CG	Smart Manufacturing Coordination Group	NA	NA

Table 2: CEN & CENELEC Committees

CEN/TC 114	Safety of Machinery	TC
Scope The Standardization of general principles for safety of machinery incorporating terminology and methodology**.**		
Committee information	**Work Programme** 5	**Standards published** 38
National Mirror Committee	NSAI/TC 048/SC 10	

CEN/TC 122	Ergonomics	TC
Scope Standardization in the field of ergonomics principles and requirements for the design of work systems and work environments, including machinery and personal protective equipment, to promote the health, safety and well-being of the human operator and the effectiveness of the work systems.		
Committee information	**Work Programme** 14	**Standards published** 126
National Mirror Committee	NSAI/TC 47/SC38	

CEN/TC 143	Machine Tools Safety	TC
Scope Standardization in the field of safety of machine tools, their accessories and tools designed to form and to machine cold metal both with and without the removal of metal.		
Committee information	**Work Programme** 4	**Standards published** 19
National Mirror Committee	No National Engagement	

CEN/TC 225	AIDC Technologies	TC
Scope Standardization of data carriers for automatic identification and data capture of the data element architecture therefore, of the necessary test specifications and of technical features for the harmonization of cross-sector applications. Establishment of an appropriate system of registration authorities, and of means to ensure the necessary maintenance of standards.		
Committee information	**Work Programme** 1	**Standards published** 20
National Mirror Committee	NSAI/TC 2/SC 9	

CEN/TC 290	Dimensional and Geometrical Product Specification and Verification	TC
Scope Standardization in the field of macro and micro-geometry specification including dimensional and geometrical tolerancing, surface properties and the related verification principles, measuring equipment and calibration requirements.		
Committee information	**Work Programme** 19	**Standards published** 121
National Mirror Committee	No National Engagement	

CEN/TC 310	Advanced automation technologies and their applications	TC
Scope Standardization in the field of macro and micro-geometry specification including dimensional and geometrical tolerancing, surface properties and the related verification principles, measuring equipment and calibration requirements.		
Committee information	**Work Programme** 2	**Standards published** 6
National Mirror Committee	No National Engagement	

CEN/TC 319	Maintenance	TC
Scope Standardization in the field of maintenance as far as generic standards which are generally applicable are concerned.		
Committee information	**Work Programme** 6	**Standards published** 7
National Mirror Committee	No National Engagement	

CEN/TC 352	Nanotechnologies	TC
Scope Standardization in the field of nanotechnologies that includes either or both of the following: • Understanding and control of matter and processes at the nanoscale, typically, but not exclusively below 100 nanometres in one or more dimensions, where the onset of size dependent phenomena usually enables novel applications; and • Utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules or bulk matter, to create improved materials, devices and systems that exploit these new properties. Specific tasks include developing standards for: classification, terminology and nomenclature; metrology and instrumentation, including specifications for reference materials; test methodologies; modelling and simulation; science-based health, safety and environmental practices; and nanotechnology products and processes. Standards in each of these areas could be specific to a product, process or industry.		
Committee information	**Work Programme** 14	**Standards published** 23
National Mirror Committee	NSAI/TC 49/SC01	

CEN/TC 368	Product Identification	TC
Scope Standardization in the field of Product as far as generic standards which are generally applicable are concerned. This committee has produced an European standard that specifies requirements for an area on the packaging - the product identification field - marked by a symbol, where clear product identification element(s) is (are) present. This European standard applies to products that are the subject of emergency enquiries to the poison information centres.		
Committee information	**Work Programme 0**	**Standards published** 1
National Mirror Committee	No National Engagement	

CEN/TC 438	Additive Manufacturing	TC
Scope Standardization in the field of Additive Manufacturing (AM)		
Committee information	**Work Programme** 26	**Standards published** 17
National Mirror Committee	NSAI/TC 49/SC 02	

CEN/CLC/JTC 13	Cybersecurity	TC

Scope

Its primary objective is to transpose relevant international standards (especially from ISO/IEC JTC 1 SC 27) as European standards (ENs) in the Information Technology (IT) domain. It also develops ‘homegrown’ ENs, where gaps exist, in support to EU regulations (RED, eIDAS, GDPR, NIS, etc.). These two streams of activities aim at creating a strategic portfolio of standards in Europe, which fits the European needs.

Committee information	**Work Programme** 10	**Standards published** 21
National Mirror Committee	NSAI/TC 2/SC 10	

CEN/CLC/JTC 14	Energy management and energy efficiency in the framework of energy transition	TC

Scope

Standardization in the field of energy management within the energy transition framework in close coordination with CEN/CENELEC sectorial strategy including, but not limited to, subjects such as:

-Energy management systems;

-Energy audits;

-Energy efficiency and energy performance improvement;

-Energy and savings calculation methodologies;

-Energy efficiency improvement financing - Energy Performance Contracting minimum requirements;

-Energy services providers; and

-Energy measurement and monitoring;

The Role of enabling technologies and RES within the energy management and energy efficiency framework taking into account the horizontal role of JTC 14 and in order to avoid overlap with scopes of other TCs, the following fields are excluded from the scope:

-Specific technologies or systems activities within the scope of other CEN, CENELEC or Joint CEN-CENELEC TCs; and

-Environmental issues.

Committee information	**Work Programme** 7	**Standards published** 9
National Mirror Committee	NSAI/TC 59	

CEN/CLC/JTC 19	Blockchain and Distributed Ledger Technologies	TC

Scope

To prepare, develop and/or adopt standards for Blockchain and Distributed Ledger technologies covering the following aspects:

- Organizational frameworks and methodologies, including IT management systems;
- Processes and products evaluation schemes;
- Blockchain and distributed ledger guidelines; and
- Smart technology, objects, distributed computing devices, data services.

The JTC will focus on European requirements, especially in the legislative and policy context, and will proceed with the identification and possible adoption of standards already available or under development in other SDOs, which could support the EU Digital Single Market and/or EC Directives/Regulations. Special attention will be paid to ISO/TC 307 standards. If required these standards will be augmented by TRs and TSs.

Committee information	**Work Programme** NA	**Standards published** NA
National Mirror Committee	NSAI/TC 2/SC 16	

CEN/CLC/BT/WG 06	ICT Standardization Policy	BT

Scope

Aims to develop ways and means for further improving the visibility and recognition of CEN and CENELEC and to draft responses to political issues in ICT Standardization context. Amongst its activities is the support to the CEN and CENELEC representatives in the European Commission's ICT Multi stakeholder Platform.

Committee information	**Work Programme** NA	**Standards published** NA
National Mirror Committee	No National Engagement	

CENELEC/TC 65X	Industrial Automation	TC

Scope

Industrial-process measurement, control and automation is responsible for the development of cybersecurity standards in the field of Operational Technology. The TC will continue the development and update of the EN IEC 62443 series "Security for industrial automation and control systems", notably via a new project on "Security program requirements for industrial automation and control systems (IACS) asset owners".

Committee information	**Work Programme** 59	**Standards published** 455
National Mirror Committee	No National Engagement	

CEN/CLC/ETSI SMa-CG	Smart Manufacturing Coordination Group	CG

Scope

The SMa-CG shall advise on ongoing European activities relating to smart manufacturing Standardization and on how they are being addressed in CEN, CENELEC and ETSI, but also to synchronise on a position of CEN, CENELEC and ETSI towards third parties concerning standardization in the field of smart manufacturing. The group shall:

• Advise the CEN/CENELEC BTs and ETSI Board on the standardization needs regarding smart manufacturing and initiate appropriate actions;

• Advise the CEN/CENELEC BTs and ETSI Board on political issues concerning smart manufacturing;

• Coordinate the various standardization activities amongst CEN, CENELEC and ETSI, taking into account the MSP/DEI WGs activities; and

• Advise CEN/CENELEC BTs and ETSI Board on ways and means to improve the visibility and recognition of CEN, CENELEC and ETSI activities in Smart Manufacturing domain.

With respect to international standardization activities on smart manufacturing, the group shall monitor the progress of the relevant standardization activities in ISO, IEC and ITU, and promote coordination between European activities and those at the international level.

With respect to links with related activities in Europe, the group should establish information exchange with relevant initiatives and interested fora and consortia. The group shall not develop standardization deliverables, but may produce information material intended for the public domain after approval by the CEN/CENELEC BTs and ETSI Board.

Committee information	**Work Programme** NA	**Standards published** NA
National Mirror Committee	No National Engagement	

IEC

The IEC is a global, not-for-profit membership organization, which publishes standards for electrical and electronic (collectively as "electrotechnology") goods. The IEC brings together more than 170 countries and provides a global, neutral and independent standardization platform to 20,000 experts globally. It administers 4 Conformity assessment systems whose members certify that devices, systems, installations, services and people work as required.

Upon admission, every IEC Member – one National Committee per country - promises to fully represent all private and public national interests in the field of electrotechnology at the global level in IEC standardization and conformity assessment activities.

The IEC publishes around 10 000 IEC international standards which together with conformity assessment provide the technical framework.

The following committees in the International Electrotechnical Commission are outlined for their standardization work in the area of Industry 4.0. The red traffic light indicates that there is no national engagement with these committees.

IEC/TC 65	Industrial-Process Measurement, Control and Automation	TC
Scope Standardization in the field of 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		
Committee information	**Work Programme** 19	**Standards published** 40
National Mirror Committee	No National Engagement	

IEC/TC 65/JWG 21	Smart Manufacturing Reference Model(s)	JWG
Scope IEC/ TC 65 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. The initial deliverable of this group, a technical report entitled, "A meta-modelling analysis approach to Smart Manufacturing Reference Models (SMRM)" will be finalized at this meeting then circulated for ballot. Work will continue on a New Project proposal for an international standard "Unified Reference Model for Smart Manufacturing." Expected attendees are subject matter experts who have been nominated to participate in JWG21 by their National Bodies. Guests are welcome to observe.		
Committee information	**Work Programme** 1	**Standards published**
National Mirror Committee	No National Engagement	

Syc SM	Smart Manufacturing	TC
Scope ISO/IEC TR 63306-2 Smart Manufacturing Standards Map (SM2) Catalogue ISO/IEC TR 63306-2 Smart Manufacturing Standards Map (SM2) Catalogue lists smart manufacturing related standards with their characteristics as specified in ISO/IEC TR 63306-1 SM2 Framework. ISO/IEC TR 63306-2 Catalogue consists of two elements: The document which describes the ISO/IEC TR 63306-2 Catalogue and provides the URL for each of the ISO and IEC repositories which contain the SM2 Catalogue. The actual information about the smart manufacturing related standards.		
Committee information	**Work Programme** 1	**Standards published 1**
National Mirror Committee	No National Engagement	

ISO

ISO, the International Organization for Standardization develops and publishes International Standards. ISO is an independent, non-governmental organization made up of members from the national standards bodies of 165 countries. There is only one member per country. Each member represents ISO in its country and counts for one vote in ISO standardization process. ISO is governed by its council and produces standards through Technical Board and committees.

At an international level within the International Organization for Standardization the following committees have been highlighted for the important standardization work in emerging technologies surrounding Industry 4.0. A traffic light system of Green or Red is used to display if the ISO Committee has a NSAI National Mirror Committee which corresponds to Y/N in the "MIRRORED" column in Table 3. Green/Y represents mirrored, while Red/N currently represents no National Mirror Committee.

COMMITTEE REFERENCE	COMMITTEE NAME	PUBLISHED STANDARDS	MIRRORED
ISO/TC 39	Machine Tools	143	N
ISO/TC 69	Applications of statistical methods	117	Y
ISO/TC 108/SC 5	Condition Monitoring and Diagnostics of Machine Systems	28	N
ISO/TC 159	Ergonomics	143	Y
ISO/TC 184	Automation Systems and Integration	860	N
ISO/TC 184/SC 4	Industrial Data	772	Y
ISO/TC 199	Safety of Machinery	43	Y
ISO/TC 213	Dimensional and Geometrical Product Specifications and Verification	150	N
ISO/TC 229	Nanotechnologies	81	Y
ISO/TC 261	Additive Manufacturing	18	Y
ISO/TC 299	Robotics	23	Y
ISO/TC 301	Energy management and energy savings	19	Y
ISO/TC 307	Blockchain and distributed ledger technologies	11	Y
ISO/SMCC	Smart Manufacturing Co Ordination Group	NA	N
ISO/IEC JTF 1	Smart Manufacturing Standards Map	NA	N

Table 3: ISO Committees

ISO/TC 39	Machine Tools	TC
Scope Standardization of all machine tools for the working of metal, wood and plastics, operating by removal of material or by pressure. SC 10 is a subcommittee of TC10 focusing on safety.		
Committee information	**Work Programme** 20	**Standards published** 163
National Mirror Committee	No National Engagement	

ISO/TC 69	Applications of statistical methods	TC
Scope Standardization in the application of statistical methods, including generation, collection (planning and design), analysis, presentation and interpretation of data. ISO Council, by Council Resolution 12 / 1959 and Council Resolution 26 / 1961 has entrusted ISO / TC 69 with the function of advisor to all ISO technical committees in matters concerning the application of statistical methods in standardization.		
Committee information	**Work Programme** 28	**Standards published** 117
National Mirror Committee	NSAI/TC 48/SC 22	

ISO/TC 108/SC 5	Condition Monitoring and Diagnostics of Machine Systems	SC
Scope Standardization of the procedures, processes and equipment requirements uniquely related to the technical activity of condition monitoring and diagnostics of machines systems in which selected physical parameters associated with an operating machine system are periodically or continuously sensed, measured and recorded for the interim purpose of reducing, analysing, comparing and displaying the data and information so obtained and for the ultimate purpose of using this interim result to support decisions related to the operation and maintenance of the machine system.		
Committee information	**Work Programme** 2	**Standards published** 28
National Mirror Committee	No National Engagement	

ISO/TC 159	Ergonomics	TC
Scope Standardization in the field of ergonomics, general ergonomics principles, anthropometry and biomechanics, ergonomics of human system interaction and ergonomics of the physical environment, addressing human characteristics and performance, and methods for specifying, designing and evaluating products, systems, services, environments and facilities. **Excluded**: Standardization of purely technical matters not related to human characteristics and abilities.		
Committee information	**Work Programme** 25	**Standards published** 143
National Mirror Committee	NSAI/TC 23/SC 5/WG 1	

ISO/TC 184	Automation Systems and Integration	TC
Scope Standardization in the field of automation systems and their integration for design, sourcing, manufacturing, production and delivery, support, maintenance and disposal of products and their associated services. Areas of standardization include information systems, automation and control systems and integration technologies. **Note:** There will be active collaboration with the relevant technical committees responsible for areas such as machines, manufacturing resources and facilities, robotics, electrical and electronic equipment, PLC for general application, quality management, industrial safety, information technologies, multi-media capabilities, and multi-modal communication networks.		
Committee information	**Work Programme** 48	**Standards published** 860
National Mirror Committee	No National Engagement	

ISO/TC 184/SC 4	Industrial Data	SC

Scope

Standardization of the content, meaning, structure, representation and quality management of the information required to define an engineered product and its characteristics at any required level of detail at any part of its lifecycle from conception through disposal, together with the interfaces required to deliver and collect the information necessary to support any business or technical process or service related to that engineered product during its lifecycle.

Note: Lifecycle includes recursive recycling to a terminal state.

Committee information	**Work Programme** 32	**Standards published** 772
National Mirror Committee	NSAI/TC 48/SC 11	

ISO/TC 199	Safety of Machinery	TC

Scope

Standardization of basic concepts and general principles for safety of machinery incorporating terminology, methodology, guards and safety devices within the framework of ISO / IEC Guide 51 and in cooperation with other ISO and IEC technical committees.

Excluded:

Product safety standards, as defined in ISO / IEC Guide 51, and which are explicitly covered by the work of other ISO or IEC technical committees.

Committee information	**Work Programme** 8	**Standards published** 43
National Mirror Committee	NSAI/TC 48/SC 10	

ISO/TC 213	Dimensional and Geometrical Product Specifications and Verification	TC

Scope

Standardization in the field of geometrical product specifications (GPS), i.e. macro - and microgeometry specifications covering dimensional and geometrical tolerancing, surface properties and the related verification principles, measuring equipment and calibration requirements including the uncertainty of dimensional and geometrical measurement. The standardization includes the basic layout and explanation of drawing indications (symbols).

Excluded:

The definition of the specific proportions and dimensions of drawing indications (symbols) and their execution.

Committee information	**Work Programme** 22	**Standards published** 150
National Mirror Committee	No National Engagement	

<table>
<tr><td>ISO/TC 229</td><td>Nanotechnologies</td><td>TC</td></tr>
<tr><td colspan="3">Scope
Standardization in the field of nanotechnologies that includes either or both of the following:
Understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometres in one or more dimensions where the onset of size-dependent phenomena usually enables novel applications; and
Utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules, and bulk matter, to create improved materials, devices, and systems that exploit these new properties.
Specific tasks include developing standards for: terminology and nomenclature; metrology and instrumentation, including specifications for reference materials; test methodologies; modelling and simulations; and science-based health, safety, and environmental practices.</td></tr>
<tr><td>Committee information</td><td>Work Programme 35</td><td>Standards published 81</td></tr>
<tr><td>National Mirror Committee</td><td colspan="2">NSAI/TC 49/SC 02</td></tr>
</table>

<table>
<tr><td>ISO/TC 261</td><td>Additive Manufacturing</td><td>TC</td></tr>
<tr><td colspan="3">Scope
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.</td></tr>
<tr><td>Committee information</td><td>Work Programme 29</td><td>Standards published 18</td></tr>
<tr><td>National Mirror Committee</td><td colspan="2">NSAI/TC 49/SC 02</td></tr>
</table>

<table>
<tr><td>ISO/TC 299</td><td>Robotics</td><td>TC</td></tr>
<tr><td colspan="3">Scope
ISO/TC 299 has the goal to develop high quality standards for the safety of industrial robots and service robots to enable innovative robotic product to be brought onto the market. In addition, ISO/TC 299 has the goal to foster the growth of the robotic market by introducing standards in fields like terminology, performance measurement and modularity. The scope of ISO/TC 299 reads “standardization in the field of robotics, excluding toys and military applications.”</td></tr>
<tr><td>Committee information</td><td>Work Programme 9</td><td>Standards published 23</td></tr>
<tr><td>National Mirror Committee</td><td colspan="2">NSAI/TC 49/SC 03</td></tr>
</table>

<table>
<tr><td>ISO/TC 301</td><td>Energy management and energy savings</td><td>TC</td></tr>
<tr><td colspan="3">Scope
Standardization in the field of energy management and energy savings.</td></tr>
<tr><td>Committee information</td><td>Work Programme 5</td><td>Standards published 19</td></tr>
<tr><td>National Mirror Committee</td><td colspan="2">NSAI/TC 59</td></tr>
</table>

ISO/TC 307	Energy management and energy savings	TC
Scope		
Standardization in the area of blockchain and distributed ledger technologies The committee has been set up to meet the growing need for standardization in this area by providing internationally agreed ways of working with it to improve security, privacy and facilitate worldwide use of the technology through better interoperability. This is especially relevant due to the number of SMEs, across various sectors, that are developing blockchain and distributed ledger technologies as a product.		
Committee information	**Work Programme** 11	**Standards published** 4
National Mirror Committee	NSAI/TC 2/SC 16	

ISO/IEC JTF 1	Smart Manufacturing Standards Map	JTF
Scope		
This Joint Task Force is a joint group between the ISO Smart Manufacturing Coordinating Committee and IEC SEG 7. Phase 1: Create an initial compilation of terms and definitions for Smart Manufacturing; • Generate and organize a definitive list of Smart Manufacturing-relevant standards from committees participating in SMCC and IEC, taking into consideration the work done to date (e.g., ISO SAG on Industry 4.0/Smart Manufacturing output, ISO/TC 184 "Big Picture", IEC TC 65 AhG3; IEC SEG 7); • Identify additional relevant Smart Manufacturing standards from other Standards Developing Organizations (SDOs), including consortia and national initiatives; • Provide an initial classification to facilitate navigation and understanding of the content; and • Publish the output of Phase 1 as an ISO/IEC Technical Report, and issue periodic updates. Phase 2: • Classify the contents of the standards map according to existing reference models and the unified reference model resulting from ISO/TC 184 – IEC/TC 65 JWG 21; and • Republish the resulting output in a maintained database format. Phase 3: In collaboration with the IEC SRG work to maintain the smart energy standards map, and with bodies developing other standards mapping tools (for example the standard mapping tool referred to in TC 184 resolution 563), develop a concept to represent the content of the Standards Map in a smart, graphically supported way to meet the needs of market users and standards developers; • Define a business case to publish the content of the Standards Map according to this concept; and • Provide a recommendation to ISO/TMB and IEC/SMB to support the realization and maintenance of the Standards Map project.		
Committee information	**Work Programme** NA	**Standards published** NA
National Mirror Committee	No National Engagement	

ISO/IEC JTC 1

This is a Joint Technical Committee between the International Organization for Standardization (ISO) and the International Electrotechnical Committee (IEC). JTC 1 is the standards development environment where experts come together to develop worldwide Information and Communication Technology (ICT) standards for business and consumer applications. JTC 1 is committed to developing, maintaining, promoting and facilitating Information Technology (IT) standards required by global markets meeting business and user requirements.

The following committees have been highlighted for the important standardization work in emerging technologies surrounding Industry 4.0. A traffic light system of Green or Red is used to display if the ISO/IEC JTC 1 Committee has a NSAI National Mirror Committee which corresponds to Y/N in the "MIRRORED" column in Table 4. Green/Y represents mirrored, while Red/N currently represents no National Mirror Committee

COMMITTEE REFERENCE	COMMITTEE NAME	PUBLISHED STANDARDS	MIRRORED
JTC 1/SC 6	Telecommunications and Information Exchange between Systems	389	Y
JTC 1/SC 24	Computer graphics, image processing and environmental data representation	85	N
JTC 1/SC 27	Information Security, Cybersecurity and Privacy Protection	198	Y
JTC 1/SC 29	Coding of audio, picture, multimedia and hypermedia information	85	Y
JTC 1/SC 31	Automatic identification and data capture techniques	128	Y
JTC 1/SC 32	Data management and interchange	28	N
JTC 1/SC 38	Cloud Computing and Distributed Platforms	21	Y
JTC 1/SC 41	Internet of Things and Related Technologies	26	Y
JTC 1/SC 42	Artificial Intelligence	6	Y

Table 4: ISO/IEC JTC 1 Committees

JTC 1/SC 6	Telecommunications and Information Exchange between Systems	SC

Scope

Since SC6 was established in 1964, SC6 has worked on standardization in the field of telecommunications dealing with the exchange of information between open systems, including system functions, procedures, parameters as well as the conditions for their use. This standardization encompasses protocols and services of lower layers including physical, data link, network, and transport as well as those of upper layers including but not limited to Directory and ASN.1: MFAN, NFC, PLC, Future Networks and OID.

Committee information	**Work Programme** 52	**Standards published** 389
National Mirror Committee	NSAI/TC 2/SC 3	

JTC 1/SC 24	Computer graphics, image processing and environmental data representation	SC

Scope

The current area of work for JTC 1/SC 24 consists of: standardization of interfaces for information technology - based applications relating to computer graphics and virtual reality, image processing, environmental data representation, support for Mixed and Augmented Reality (MAR), and interaction with, and visual presentation of information.

Committee information	**Work Programme** 8	**Standards published** 85
National Mirror Committee	No National Engagement	

JTC 1/SC 27	Information Security, Cybersecurity and Privacy Protection	SC

Scope

The development of standards for the protection of information and ICT. This includes generic methods, techniques and guidelines to address both security and privacy aspects, such as:

- Security requirements capture methodology;
- Management of information and ICT security; information security management systems, security processes, and security controls and services;
- Cryptographic and other security mechanisms, including but not limited to mechanisms for protecting the accountability, availability, integrity and confidentiality of information;
- Security management support documentation including terminology, guidelines as well as procedures for the registration of security components;
- Security aspects of identity management, biometrics and privacy;
- Conformance assessment, accreditation and auditing requirements in the area of information security management systems; and
- Security evaluation criteria and methodology.

SC 27 engages in active liaison and collaboration with appropriate bodies to ensure the proper development and application of SC 27 standards and technical reports in relevant areas.

Committee information	**Work Programme** 87	**Standards published** 198
National Mirror Committee	NSAI/TC 2/SC 10	

JTC 1/SC 29	Coding of audio, picture, multimedia and hypermedia information	SC

Scope

Standardization of coded representation of audio, picture, multimedia and hypermedia information and sets of compression and control functions for use with such information such as:

Audio information, Bi-level and Limited Bits-per-pixel Still Pictures, Digital Continuous-tone Still Pictures, Computer Graphic Images, Moving Pictures and Associated Audio, Multimedia and Hypermedia Information for Real-time Final Form Interchange, Audio Visual Interactive Script ware.

Excluded: Character Coding.

Committee information	**Work Programme** 8	**Standards published** 85
National Mirror Committee	NSAI/TC 2/SC 03/WG01	

JTC 1/SC 31	Automatic identification and data capture techniques	TC

Scope

Standardization of data formats, data syntax, data structures, data encoding, and technologies for the process of automatic identification and data capture and of associated devices utilized in inter-industry applications and international business interchanges and for mobile applications.

These standards include the ubiquitous EAN/UPC barcode found on consumer goods and healthcare products, the popular QR Code used by many applications to access data on the web and ISO/IEC 18000-63, the most widely implemented radio-frequency identification standard for item management.

Committee information	**Work Programme** 21	**Standards published** 128
National Mirror Committee	NSAI/TC 2/SC 9	

JTC 1/SC 32	Data management and interchange	SC

Scope

Standards for data management within and among local and distributed information systems environments. SC 32 provides enabling technologies to promote harmonization of data management facilities across sector-specific areas. Specifically, SC 32 standards include:

• Reference models and frameworks for the coordination of existing and emerging standards;

• Definition of data domains, data types, and data structures, and their associated semantics;

• Languages, services, and protocols for persistent storage, concurrent access, concurrent update, and interchange of data; and

• Methods, languages, services, and protocols to structure, organize, and register metadata and other information resources associated with sharing and interoperability, including electronic commerce.

Committee information	**Work Programme** 45	**Standards published** 95
National Mirror Committee	No National Engagement	

JTC 1/SC 38	Cloud Computing and Distributed Platforms	SC

Scope

Standardization in the areas of Cloud Computing and Distributed Platforms including:

- Foundational concepts and technologies;
- Operational issue; and
- Interactions among Cloud Computing systems and with other distributed systems.

SC 38 serves as the focus, proponent, and systems integration entity on Cloud Computing, Distributed Platforms, and the application of these technologies. SC 38 provides guidance to JTC 1, IEC, ISO and other entities developing standards in these areas.

Committee information	**Work Programme** 6	**Standards published** 21
National Mirror Committee	NSAI/TC 2/SC 11	

JTC 1/SC 41	Internet of Things and Related Technologies	SC
Scope Standardization in the area of Internet of Things and related technologies. Serve as the focus and proponent for JTC 1's standardization programme on the Internet of Things and related technologies, including Sensor Networks and Wearables technologies. Provide guidance to JTC 1, IEC, ISO and other entities developing Internet of Things related applications.		
Committee information	**Work Programme** 7	**Standards published** 26
National Mirror Committee	NSAI/TC 2/SC 11	

JTC 1/SC 42	Artificial Intelligence	SC
Scope Standardization in the area of Artificial Intelligence: • Serve as the focus and proponent for JTC 1's standardization program on Artificial Intelligence • Provide guidance to JTC 1, IEC, and ISO committees developing Artificial Intelligence applications		
Committee information	**Work Programme** 21	**Standards published** 6
National Mirror Committee	NSAI/TC 2/SC 18	

ETSI

European Telecommunications Standards Institute (ETSI) is an European Standards Organization (ESO). They are the recognised regional standards body dealing with telecommunications, broadcasting and other electronic communications networks and services. They have a special role in Europe which includes supporting European regulations and legislation through the creation of harmonised European standards. Only the standards developed by the three ESOs (CEN, CENELEC and ETSI) are recognized as European standards (ENs).

NSAI is also a member of the ETSI, which employs a different membership participation model to which NSAI does not facilitate memberships. ETSI has Industrial Specification groups (ISG) as well as Technical Committees carrying out standardization work outlined in Table 5.

COMMITTEE REFERENCE	COMMITTEE NAME	PUBLISHED STANDARDS	MIRRORED
ETSI TC CYBER	Cyber	45	N
ETSI TC SmartM2M	Smart Machine-to-Machine Communications	85	N
ETSI ISG SAI	Securing Artificial Intelligence	1	N
ETSI TC ERM	EMC and Radio Spectrum Matters	728	N
ETSI TC ESI	Electronic Signatures and Infrastructures	258	N
ETSI TC SmartBAN	Smart Body Area Network	7	N
ETSI ISG ARF	Augmented Reality Framework	3	N
ETSI ISG CIM	Cross Cutting Context Information Management	9	N
ETSI ISG MEC	Multi-access Edge Computing	N/A	N
ETSI ISG PDL	Permissioned Distributed Ledger	17	N

Table 5: ETSI Committees

ETSI/Cyber	Cyber	TC

Scope

ETSI TC CYBER is recognized as a major trusted centre of expertise offering market-driven cybersecurity standardization solutions, advice and guidance to users, manufacturers, network, infrastructure and service operators and regulators. ETSI TC CYBER works closely with stakeholders to develop standards that increase privacy and security for organizations and citizens across Europe and worldwide. They provide standards that are applicable across different domains, for the security of infrastructures, devices, services, protocols, and to create security tools and techniques.

Committee information	**Work Programme**	**Standards published** 45
National Mirror Committee	No National Engagement	

ETSI/SmartM2M	Smart Machine-to-Machine Communications (SMARTM2M)	TC

Scope

ETSI are developing standards to enable M2M services and applications and certain aspects of the Internet of Things (IoT).They are a partner in one M2M and help to produce the specifications to enable users to build platforms by which devices and services can be connected, regardless of the underlying technology used.

Their work enables connected devices to exchange information through SAREF, their smart applications reference ontology that runs with one M2M-compliant communication platforms. With SAREF, SmartM2M is promoting one M2M Base Ontology with extensions in many IoT domains.

Committee information	**Work Programme**	**Standards published** 85
National Mirror Committee	No National Engagement	

ETSI ISG SAI	Securing Artificial Intelligence	ISG

Scope

The SAI develops technical specifications and reports to address 3 aspects of artificial intelligence in standards:

Securing AI from attack: where AI is a component in a system that needs protection

Mitigating against malicious AI: where AI is used to improve and enhance conventional attack vectors, or create new attack vectors

Using AI to enhance security measures: protecting systems against attack where using AI is part of the ‘solution’ or is used to improve and enhance more conventional countermeasures

The ETSI ISG SAI develops the technical knowledge that acts as a baseline in ensuring that artificial intelligence is secure. Stakeholders impacted by the activity of ETSI’s group include end users, manufacturers, operators and governments.

Committee information	**Work Programme**	**Standards published** 1
National Mirror Committee	No National Engagement	

ETSI TC ERM	EMC and Radio Spectrum Matters	TC

Scope

This committee is responsible for a range of radio product and electromagnetic compatibility (EMC) standards and the overall co-ordination of radio spectrum matters.

For many years they have provided more than 75% of the harmonised standards required under the R&TTE Directive until the arrival of the Radio Equipment Directive in June 2016. The RED has implications for ETSI’s radio work, especially in relation to receivers, software defined radio and cognitive radio. After review and alignment, TC ERM is currently maintaining nearly 150 harmonised standards related to the RED.

Since the scope of the RED is broader than the R&TTE Directive, they develop new harmonised standards in areas such as radio and TV broadcast receivers, equipment below 9 kHz and radio determination equipment which were not addressed previously.

The committee liaise with a number of EC groups in which ETSI is an observer, in particular the Expert Group of the Telecommunication Conformity Assessment and Market Surveillance Committee (TCAM), the Radio Spectrum Policy Group (RSPG) and the Radio Spectrum Committee (RSC). They also work closely with the CEPT Electronic Communications Committee (CEPT/ECC), the Radio Equipment Compliance Association (REDCA) and the market surveillance and conformity assessment authorities through ADCO RED (Group of Administrative Co-operation under the RED).

Committee information	**Work Programme**	**Standards published** 728
National Mirror Committee	No National Engagement	

ETSI TC ESI	Electronic Signatures and Infrastructures	TC

Scope

The work deals with digital signatures and related trust services.

This activity covers the format of digital signatures, as well as procedures and policies for creation and validation. TC ESI also covers policy, security and technical requirements for trust service providers (TSP) such as certification authorities, time-stamping authorities, TSP providing remote signature creation or validation functions, registered e-delivery providers, and long-term data preservation providers. We address Trusted Lists that enhance the confidence of parties relying on certificates or other services related to digital signatures by indicating whether a given TSP was operating under the approval of any recognized scheme.

This work also aims at supporting the eIDAS Regulation as well as the general requirements of the international community to provide trust and confidence in electronic transactions).

Committee information	**Work Programme**	**Standards published** 258
National Mirror Committee	No National Engagement	

ETSI TC SmartBAN	Smart Body Area Network	TC

Scope

We are responsible for standardization to support the development and implementation of Smart Body Area Network (BAN) technologies (Wireless BAN, Personal BAN, Personal Networks etc.) in health, wellness, leisure, sport and other relevant domains. This technology uses small, low power devices to support a range of medical, health improvement, personal safety and wellbeing, sport and leisure applications.

Committee information	**Work Programme**	**Standards published** 7
National Mirror Committee	No National Engagement	

ETSI ISG ARF	Augmented Reality Framework	ISG

Scope

Augmented Reality Framework defines a framework for the interoperability of Augmented Reality (AR) components, systems and services that specifies relevant components and interfaces required for an AR solution. Augmented Reality is the ability to mix in real-time spatially-registered digital content with the real world surrounding the user.

The development of a modular architecture will allow components from different providers to interoperate through the defined interfaces. Transparent and reliable interworking between different AR components is key to the successful roll-out and wide adoption of AR applications and services.

The availability of an interoperability framework for AR:

- Encourage an ecosystem with a diverse range of solution providers including smaller players, new entrants and academics;
- Prevent market fragmentation and break vertical siloes;
- Enable providers to offer part(s) of an overall AR solution; and
- Give end-users confidence to invest in future proof AR solutions knowing that they can swap technology as and when the need arises.

Committee information	**Work Programme**	**Standards published** 3
National Mirror Committee	No National Engagement	

[ETSI ISG CIM](#)	Cross Cutting Context Information Management	ISG

Scope

This 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.

Their Application Programming Interface Specification/API (named NGSI-LD with OMA authorization) aims to enable applications to discover, access, update and manage data and context information from many different sources as well as to publish it through interoperable data publication platforms like Open Data platforms.

Committee information	**Work Programme**	**Standards published** 9
National Mirror Committee	No National Engagement	

[ETSI ISG MEC](#)	Multi-access Edge Computing	ISG

Scope

Multi-access Edge Computing (MEC) offers application developers and content providers cloud-computing capabilities and an IT service environment at the edge of the network. This environment is characterized by ultra-low latency and high bandwidth as well as real-time access to radio network information that can be leveraged by applications.

MEC is a natural development in the evolution of mobile base stations and the convergence of IT and telecommunications networking. Multi-access Edge Computing will enable new vertical business segments and services for consumers and enterprise customers. Use cases include:

- Video analytics;
- Location services;
- Internet-of-Things (IoT);
- Augmented reality;
- Optimized local content distribution; and
- Data caching.

Committee information	**Work Programme**	**Standards published** 46
National Mirror Committee	No National Engagement	

ETSI ISG PDL	Permissioned Distributed Ledger	ISG

Scope

To analyse and provide 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.

While distributed ledgers are mostly known because of their use as cryptocurrencies, there are many other uses besides those, with examples such as the so-called smart contracts, support to digital identity attributes, object tracking, or the verification of service level agreements.

Committee information	**Work Programme**	**Standards published** 5
National Mirror Committee	No National Engagement	

Conclusion

Industry 4.0 or the fourth Industrial Revolution represents a complex series of transformations that will lead to new definitions for our interactions with our built and natural environments, digital changes in the industrial markets with smart manufacturing at the forefront.

"Trends in manufacturing are moving towards seamless integration of physical and digital worlds in order to enable fast integration, feedback and control loops throughout distributed manufacturing infrastructures. The increasing adoption of information and communication technologies (ICT) in the manufacturing domain not only leads to more efficient and technologically sophisticated production systems, but also enables the implementation of innovative business models."[52]

Standards are one of the key drivers for this innovation, making yesterday's impossibilities tomorrow's reality. This is happening through the development of relevant resources such as technical reports, technical specifications, publicly available specifications and standards by technical committees at a regional European and further international level. Their work will help enable the use of smart data and digital technologies to improve business processes and production systems. Our aim is to take concrete steps to create adequate conditions and remove possible obstacles through standardization, in order to seize upon the opportunities of IT - OT convergence (information technology – operational technology).

[52] https://www.anixter.com/content/dam/Suppliers/Hitachi/iecWP-futurefactory-LR-en.pdf

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