ZDMP: Zero Defects Manufacturing Platform

WP4: Technical Challenge: Requirements, Specifications, and Standardisation

D4.6a: Standardisation Plan and Status Report - Vs: 1.0.6

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Contributing Partners: All Partners

Date: 2019-09

Dissemination: Public

Status: EU Approved

Abstract

ZDMP sets three standardisation goals: Interaction: Establish contact to relevant groups to receive and provide information; Compliance: Monitor the use of standards in the project to foster compliant results; and Input: Engage in standardisation to exploit project results. This deliverable describes how these goals will be reached and how standardisation will contribute to an easier market access of ZDMP and the successful exploitation of project results across its duration.

Grant Agreement: 825631

Document Status

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Internal Reviewer 1	Marc Dorchain, SAG
Internal Reviewer 2	Juan Pardo, CET
Internal Reviewer 3	Stuart Campbell, ICE
Type	Deliverable
Work Package	WP4: Technical Challenge: Requirements, Specifications, and Standardisation
ID	D4.6a: Standardisation Plan and Status Report
Due Date	2019-09
Delivery Date	2019-09
Status	EU Approved

Project Partners:

For full details of partners go to www.zdmp.eu/partners

Executive Summary

Standards support three of the main objectives in ZDMP: Extensibility, interoperability. and openness. By compliance with international standards, interoperability is fostered the most. Companies around the world use standardised interfaces, enabling the communication and thus the collaboration between different software packages or whole machines. The definition of standardised interfaces is open in a way that it is accessible by everyone which enables different stakeholders to create compatible programs or devices. By supporting the most used interfaces, ZDMP will be able to run in many factories, thus accessing a huge market.

ZDMP creates an open ecosystem, where developers can offer additional modules to extend the range of functions. A standardised interface of ZDMP with these modules could ensure an open and transparent environment, giving developers security and minimizing errors. This can be especially valuable and reassuring in the ZDMP subcalls as well.

To utilise standardisation most efficiently, ZDMP sets the following standardisation goals:

- **Interaction**: Establish contact to relevant groups to receive and provide information
- **Compliance**: Monitor the use of standards in the project to foster compliant results
- **Input**: Engage in standardisation to exploit project results

Upon an analysis of the current standardisation landscape with respect to ZDMP, this deliverable describes how these goals can be achieved and proposes certain actions in the recommendation section. Since different project partners are already members in different standardisation consortia, a solid interaction with standardisation is already established and will be improved. The project partners provided a first evaluation of which standards are important and which standards will be used. Topics, suitable for input to standardisation were identified and ZDMP expects to achieve the creation of one CEN Workshop Agreement (CWA) and is motivated to create up to three CWAs. This includes a CWA to be envisaged in cooperation with the H2020-projects eFactory and Qu4lity which is also mentioned in the cluster cooperation informal deliverable DX1.

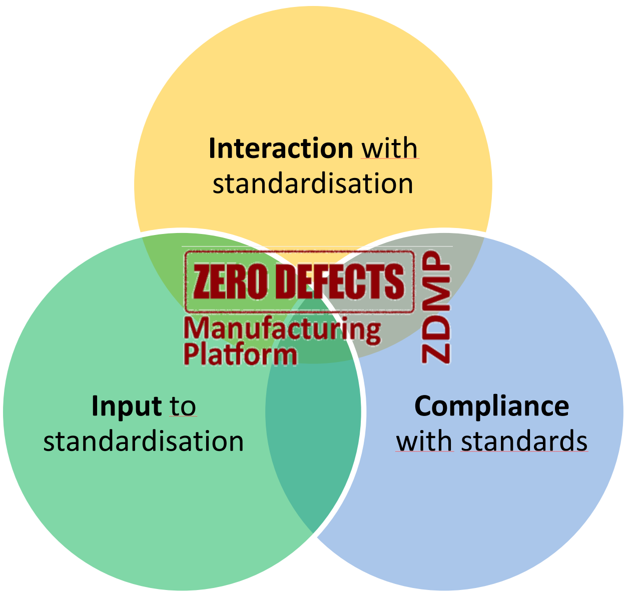

Figure 1: Standardisation goals of ZDMP

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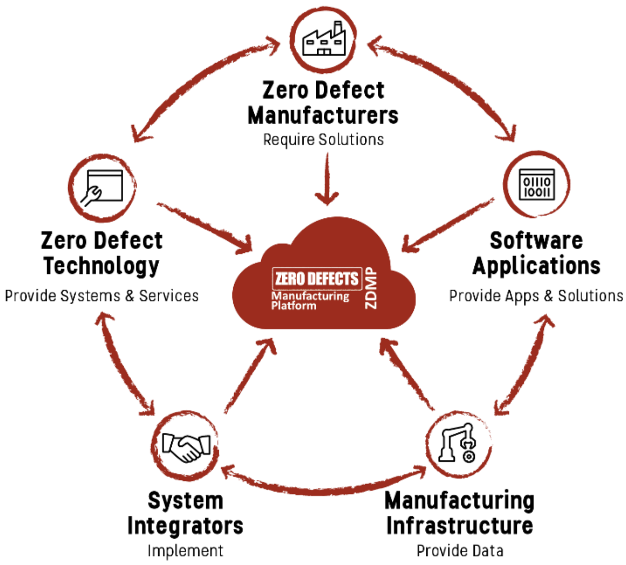
0 Introduction

0.1 ZDMP Project Overview

ZDMP – Zero Defects Manufacturing Platform – is a project funded by the H2020 Framework Programme of the European Commission under Grant Agreement 825631 and conducted from January 2019 until December 2022. It engages 30 partners (Users, Technology Providers, Consultants and Research Institutes) from 11 countries with a total budget of circa 16.2M€. Further information can be found at www.zdmp.eu.

In the last five years, many industrial production entities in Europe have started strategic work towards a digital transformation into the fourth-industrial revolution termed Industry 4.0. Based on this new paradigm, companies must embrace a new technological infrastructure, which should be easy to implement for their business and easy to implement with other businesses across all their machines, equipment, and systems. The concept of zero-defects in the management of quality is one of the main benefits deriving from the implementation of Industry 4.0, both in the digitalisation of production processes and digitalisation of the product quality.



To remain competitive and keep its leading manufacturing position, European industry is required to produce high quality products at a low cost, in the most efficient way. Today, manufacturing industry is undergoing a substantial transformation due to the proliferation of new digital and ICT solutions, which are applied along the production process chain and are helping to make production more efficient, as in the case of smart factories. The goal of the ZDMP Project is to develop and establish a digital platform for connected smart factories, allowing achieving excellence in manufacturing through zero-defect processes and zero-defect products.

ZDMP aims at providing such an extendable platform for supporting factories with a high interoperability level, to cope with the concept of connected factories to reach the goal of zero-defect production. In this context, ZDMP will allow end-users to connect their systems (ie shop-floor and Enterprise Resource Planning systems) to benefit from the features of the platform. These benefits include product and production quality assurance amongst others. For this, the platform provides the tools to allow following each step of production, using data acquisition to automatically determine the functioning of each step regarding the quality of the process and product. With this, it is possible to follow production order status and optimize the overall processes regarding time constraints and product quality, achieving the zero defects.

0.2 Deliverable Purpose and Scope

The purpose of this document "D4.6a Standardisation Plan and Status Report" is to point out how to achieve the ZDMP standardisation goals: Interaction with standardisation, Input to standardisation and Compliance with existing standards.

Furthermore, it will provide an overview about the current standardisation landscape in the field of zero defects manufacturing and outline the possibilities to contribute to standardisation.

Specifically, the DOA states the following regarding this Deliverable:

O4.6 To define and provide standardisation input and engagement

T4.6	**Standardisation**	**DIN**	**M9-12, 10-36**		
D4.6ab	Standardisation Plan and Status Report	R	PU	12,36	RDI2 & 6
This task will cover all standardisation activities of the project. The goals are to connect to standardisation forums and to monitor the project to ensure a compliance of the project results in existing standards. The project will also actively contribute to standardisation by eg participating at DIN or CEN working groups and possibly prepare to undertake input to the standardisation process for those project results that will seem most suitable. ZDMP will engage with the European standardisation process, specifically CEN and DIN, along with other standardisation bodies. Standardisation activities will use the "Standardisation guidelines for ICT research projects interfacing with ICT standards organizations" by the COoperation Platform for Research and Standards (COPRAS). DIN, German Standards, is a member of the consortium and German Industry is at the focus of I4.0, Thus the ZDMP project will be in an ideal position to provide the right level of standards-interfacing with all RTD partners from WP5-8 required to interface into this tasks to support it.					

0.3 Target Audience

The Standardisation Plan aims primarily at project participants, although in addition, it provides the European Commission and experts from different projects with an overview of ZDMP's standardisation approach.

0.4 Deliverable Context

This document relates to other documents as follows:

Primary Preceding documents:

- Manufacturing Reference Model Analysis (ZDMP D2.4). Here, different standardised reference models are described, and their commonalities and differences are analysed. Different recommendations for various tasks result from the analysis, including for Task 4.6.

Primary Dependant documents:

- None

0.5 Document Structure

This deliverable is broken down into the following sections:

- **Section 1: Current Standardisation Landscape:** Information about most relevant standardisation committees, consortia and current activities
- **Section 2: Standardisation Process:** Gives an overview of a standardisation process and options to interact and contribute
- **Section 3: Standardisation in ZDMP:** Presents a strategy how ZDMP can ensure compliance with relevant standards, interact with standardisation and give input to standards
- **Section 4: Recommendations:** Provides a detailed list of recommended actions
- **Section 5: Conclusion:** Concludes the standardisation plan of ZDMP

- **Annexes**:
  - **Annex A**: Document History
  - **Annex B**: References
  - **Annex C**: List of ZDMP Related Standards

0.6 Document Status

This document is listed in the Description of Action as "public" since standardisation is naturally open and transparent.

0.7 Document Dependencies

This document is part one of a living deliverable with two iterations. This first iteration focuses on the actions to be taken. In the second version, a chapter on the work carried out will be added to complete the document. The second and final iteration will be delivered at M48 at the end of the project.

0.8 Glossary and Abbreviations

A definition of common terms related to ZDMP, as well as a list of abbreviations, is available at http://www.zdmp.eu/glossary.

0.9 External Annexes and Supporting Documents

- None

0.10 Reading Notes

- None

1 Current Standardisation Landscape

1.1 Benefits of Standardisation

Standardisation facilitates the exchange of goods, processes, and services by eliminating technical barriers. From the size of credit cards, to petrol, to and train tracks: All of these things are standardized and can be used in different countries across the world. The producers benefit from the raised transferability and marketability of innovations. Thereby consumers and producers benefit from standardisation through increased quality (eg guaranteed conformance) as well as lower prices (eg common components such as screw sizes).

Products can reach by a far larger market with lower development and testing costs. Manufacturers benefit from being able to use a broader basis of external suppliers, from greater quality assurance, and increased efficiency. Additionally, customers are more likely to accept trustworthy products or services.

Concisely, the benefits of standardisation are:

- Dissemination and application of innovations:
    - Promotion of worldwide trade
    - Standardizing interfaces enhances compatibility
- Time advantage and knowledge lead:
    - Preview of what is happening on the market
- Lower R&D risks and costs
- Assurance of quality
- Environmental protection
- Improving communication and information exchange

Strategic motives for companies to participate in standardisation can also be the ability to design industry friendly regulations, enforce own content, prevent formal standards from conflicting with own interests, solve industry specific technical problems, and acquire competitive advantages through a head start in knowledge.

1.2 ZDMP Related Standards

1.2.1 General

ZDMP aims to create an industrial software platform which is capable of analysing data from various machines and sensors to actively reduce the number of defective parts or optimise processes. Accordingly, ZDMP touches the fields of Zero Defects, smart manufacturing (also called I4.0), cloud-platforms, predictive maintenance, and services on platforms.

The field of Information and Communication Technology (ICT) is very agile and many different organisations and consortia are developing standards and specifications. Two EU funded projects had the task to get an overview of the standardisation landscape and make this overview accessible. The COoperation Platform for Research and Standards (COPRAS) was funded within the FP6 program. One of its deliverables was an important guideline for research projects which are planning to interface with standardisation in the field of ICT. ZDMP uses the recommendations of COPRAS and recommendations that are currently being developed in the H2020 HARMONI project for research projects in the process industry, as a basis for its standardisation work. A further important H2020 project is StandICT.eu; it provides a selection of the most relevant standards in this field.

ZDMP is not working in isolation and is favourable, progressive, and has taken the lead in relevant cross-project collaboration activity. The parallel funded platform project eFactory, dealing with lot size 1 manufacturing, has several common partners and aims with ZDMP and the management of both projects have been extremely active to mandate and stimulate cooperation between them. A third project, Qu4lity, which is also on zero-defects manufacturing has also be engaged with but there is more limited cross-over of activity and partners. In particular, the Austrian standards body, Austrian Standards International (ASI), is the ‘standards’ project partner eFactory and in any case DIN and ASI have a close wider cooperation. Both DIN and ASI also have experience in the field of I4.0. Thus DIN/ASI and ZDMP/eFactory have worked/are working closely together on a standards approach which can leverage both projects.

A comprehensive list of ZDMP related standards can be found in Annex C on page 37 and following pages. The list is based on standard researches of ASI, DIN, and StandICT.eu, including a consultation of DIN internal I4.0 experts and experts from the projects ZDMP and eFactory.

1.2.2 Zero Defects

Zero defects is a strategy to avoid the production of defective parts. As a specific strategy to reach a high quality, it was the precursor of modern quality management. While quality management standards are omnipresent, the keyword "zero defects", describing a certain direction of quality management, can only be found in relatively few standards, mainly dealing with fasteners, electrical resistors, and lean production.

Fasteners:

- **ISO 1891-4:2018** Fasteners – Vocabulary – Part 4: Control, inspection, delivery, acceptance and quality
  "zero defect concept"
  "objective that no fasteners with defect(s) are present, within a given manufacturing lot, which could impair their expected or intended use"
- **ISO 16426:2002** Fasteners – Quality assurance system
  "zero defect conception"
  "conception that establishes an objective that no fasteners with defects are present, within a given mechanical fastener lot, which impair their expected or intended use"

Resistors:

- **EN 140402-801:2015** Detail specification: Fixed low power wire-wound surface mount (SMD) resistors – Rectangular – Stability classes 0,5; 1; 2
  The allowed number of nonconformities in a lot is set to 0

Lean production:

- **VDI 2870 Blatt 1:2012** Lean production systems – Basic principles, introduction, and review
  "Zero defects principle"

> "This principle means avoiding the carryover of defects and ensuring a high quality of work results and processes. This requires systematic checking of work results and process steps in short cycles during planning and production. The further downstream a defect is carried, the more expensive its correction will be."
> Makes use of one or several methods such as: "5 why, 8D report, A3 method, autonomation, Ishikawa diagram, short control loops, Poka-yoke, Six Sigma, statistical process control and worker self-control"

The definition used in connection with fasteners is extremely strict. It does not give a ratio such as “one in a thousand” or “one in a million”. It sees zero defects as specifically “zero”. The second concept regarding this definition is that a defect only relates to the intended use, not other properties such as colour, which are not connected to the intended use. This is in line with the definition used in connection with resistors. If one resistor fails, the whole lot will be rejected. In connection with lean production, a brief description of Zero Defects as a principle and corresponding methods can be found in a VDI guideline[1].

From these findings, there is no Technical Committee which is mainly responsible for zero defects standards. At international level, it would fit best to ISO/TC 176, Quality management and quality assurance. Its scope is: Standardisation in the field of quality management (generic quality management systems and supporting technologies), as well as quality management standardisation in specific sectors at the request of the affected sector and the ISO Technical Management Board. ISO/TC 176 is responsible for the development of ISO 9000, ISO 9001, and similar standards. As the Zero Defects principle is a form of quality management, ISO/TC 176 should have contacts to experts in this field.

1.2.3 Smart Manufacturing

The field of smart manufacturing (also called Industry 4.0 or I4.0) is very agile and forward-looking. Due to both, the agility of the field and its position between electronics, telecommunication and other areas, different consortia exist. Some of these consortia create internationally well accepted standards. This field also sees more streamlined standardisation procedures to create pre-standard-like documents offered by the official standards bodies. For example, ISO and IEC offer the international workshop agreement (IWA) at international level, CEN and CENELEC offer the CEN workshop agreement at European level, and DIN offers the DIN SPEC at national level. Many of the standards elaborated in consortia or pre-standards are taken over by the international standardisation system as ie ISO or IEC standard. The most prominent consortia are: OPC, IEEE, W3C, and oneM2M.

In the field of I4.0, the need to discover and focus the needs of all different stakeholders and to find common solutions lead to the formation of different platforms at national and international level. One example for such a platform on European level is the Alliance for Internet of Things Innovation (AIOTI)[2] which was founded by the European Commission to connect different stakeholders, espacially in the field of IoT. At a national level, an example is the "Plattform Industrie 4.0"[3]. At the European level, a group, especially for the coordination of standardisation activities, the CEN-CENELEC-ETSI Coordination Group on Smart Manufacturing has been recently founded. Its main objectives are to advise the three European standardisation organisations CEN, CENELEC, and ETSI in

[1] VDI guidelines are industry standards, developed by the German association of engineers (VDI).

[2] See: https://aioti.eu/

[3] See: https://www.plattform-i40.de/PI40/Navigation/EN/Home/home.html

standardisation needs and political issues and to synchronize the standardisation activities concerning smart manufacturing in Europe. At the international level, ISO has established the "ISO Smart Manufacturing Coordinating Committee (ISO/SMCC)" where representatives were nominated from a total of 21 ISO committees, in addition to one representative each from the IEC (electronics) and the ITU (tele communication) to take part in the collaboration.

In addition to Europe, the USA and China are key players and important cooperation partners and hence international collaboration such as the above is essential.

One of the most important aspects in smart manufacturing is the interoperability between the various types of machines, sensors, and devices. Unified connections between them and the overall semantics can be seen as enabler for smart manufacturing and as one of the main tasks of standardisation.

The most important standards to ensure interoperability are perceived to be:

- **OPC UA (IEC 62541 series)** – OPC Unified Architectures
  OPC UA Open Platform Communications United Architecture
  Series of standards, developed by the OPC foundation
- **W3C** World Wide Web Consortium standards
  HTML, XHTML, XML, RDF, OWL, CSS, SVG
- **MQTT (ISO/IEC 20922:2016)** – Information technology – Message Queuing Telemetry Transport (MQTT) v3.1.1
  Message Queuing Telemetry Transport is a publish-subscribe-based messaging protocol. It works on top of the TCP/IP protocol
- **ETSI TS 118112 V 2.0.0:2016** – oneM2M – Base Ontology
  Contains the specification of the oneM2M base ontology

The most important committees regarding ZDMP are:

- **OPC** – Open Platforms Communications
  OPC is the interoperability standard for the secure and reliable exchange of data in the industrial automation space and in other industries. It is platform independent and ensures the seamless flow of information among devices from multiple vendors. The OPC Foundation is responsible for the development and maintenance of this standard. With the introduction of service-oriented architectures in manufacturing systems, new challenges in security and data modelling have emerged. The OPC Foundation developed OPC UA specifications to address these needs and at the same time provided a platform architecture that was relatively rich in features, open for any technologies, future-proof, scalable, and extensible.
- **oneM2M** – Standards for M2M and the Internet of Things
  The purpose and goal of oneM2M is to develop technical specifications which address the need for a common M2M Service Layer that can be readily embedded within various hardware and software. Its purpose is to be relied upon to connect the myriad of devices in the field with M2M application servers worldwide. A critical objective of oneM2M is to attract and actively involve organisations from M2M-related business domains such as: Telematics, intelligent transportation, healthcare, utilities, industrial automation, smart homes, etc. Initially, oneM2M aim is to prepare, approve, and maintain the necessary set of Technical Specifications and Technical Reports related to its goals.

- **IEEE** – Institute of Electrical and Electronics Engineers
  Standardisation in the field of electrical and electronic engineering, and telecommunications
- **IEC/TC 2** – Rotating machinery
  To prepare international standards regarding specifications for rotating electrical machines without limitations of voltage, output, or dimensions with the exception of the following:
  - Traction motors within the scope of TC 9: Electric railway equipment
  - Motors and generators within the scope of TC 69: Electric road vehicles and electric industrial trucks
  - Motors and generators for use in cars and commercial vehicles
  - Motors and generators for use in aeronautics or space applications
- **IEC/TC 22/SC 22G** – Adjustable speed electric drive systems incorporating semiconductor power converters
  To prepare international standards for electronic power conversion equipment in adjustable speed electric drive systems, including the means for their control, protection, monitoring and measurement. Excluded are traction applications and electric vehicles.
- **IEC/TC 56** – Dependability
  To prepare international standards in the field of dependability, in all appropriate technological areas, including those not usually handled by IEC Technical Committees. Dependability is the ability to perform as required and when required and is time dependent in application. Dependability can be expressed in terms of core attributes of availability, reliability, maintainability, and supportability that are tailored to application-specific functional and service attributes. TC 56 standards are related to products, processes, and management activities. The standards provide systematic methods and tools for dependability assessment, technical risk assessment and management of services and systems throughout their life cycles. Dependability is a technical discipline that is important in quality management, asset management, risk management and financial decision making. It is managed through life cycle processes involving availability and its core performance attributes of reliability, maintainability, and supportability, as well as application-specific performance attributes such as recoverability, survivability, integrity, security for products, and service dependability evaluation.
- **IEC/TC 65** – Industrial-process measurement, control, and automation
  To prepare international standards for systems and elements used for industrial process measurement, control, and automation. To coordinate standardisation activities which affect integration of components and functions into such systems including safety and security aspects. This work of standardisation is carried out in the international fields for equipment and systems.
- **IEC/TC 65/SC 65B** – Measurement and control devices
  To prepare international standards in the field of specific aspects of devices (hardware and software) used in industrial process measurement and control, such as measurement devices, analysing equipment, actuators, and programmable logic controllers, and covering such aspects as interchangeability, performance evaluation, and functionality definition.
- **IEC/TC 65/SC 65E** – Devices and integration in enterprise systems
  To prepare international standards specifying:

  - Device integration with industrial automation systems. The models developed in these standards address device properties, classification, selection, configuration, commissioning, monitoring and basic diagnostics
  - Industrial automation systems integration with enterprise systems. This includes transactions between business and manufacturing activities which may be jointly developed with ISO TC184.

- **ISO/IEC JTC 1** – Information Technology
  International standardisation in the field of Information Technology. Information Technology includes the specification, design, and development of systems and tools dealing with the capture, representation, processing, security, transfer, interchange, presentation, management, organisation, storage, and retrieval of information. JTC 1 is the standards development environment where experts come together to develop worldwide Information and Communication Technologies (ICT) standards for business and consumer applications. Additionally, JTC 1 provides the standards approval environment for integrating diverse and complex ICT technologies. These standards rely upon the core infrastructure technologies developed by JTC 1 centres of expertise complemented by specifications developed in other organisations.
- **ISO/IEC JTC 1/SC 7** – Software and systems engineering
  SC7 delivers standards in the area of software and systems engineering that meet market and professional requirements. These standards cover the processes, supporting tools and supporting technologies for the engineering of software products and systems. Systems engineering, whose origin is traceable to industrial engineering, is defined as an interdisciplinary approach governing the total technical and managerial effort required to transform a set of customer needs, expectations, and constraints into a solution and to support that solution throughout its life. SC7, whose scope is Software and Systems Engineering, can thus be described as a horizontal committee which produces generic standards that are technology-agnostic and independent of the application domain. These standards are principally focused on process models and good practices (Methods and techniques).
- **CEN/CLC/JTC 13** – Cyber security and data protection
  Development of standards for cybersecurity and data protection covering all aspects of the evolving information society including but not limited to: Management systems, frameworks, methodologies; Data protection and privacy; Services and products evaluation standards suitable for security assessment for large companies and small and medium enterprises (SMEs); Competence requirements for cybersecurity and data protection; Security requirements, services, techniques and guidelines for ICT systems, services, networks and devices, including smart objects and distributed computing devices. Included in the scope is the identification and possible adoption of documents already published or under development by ISO/IEC JTC 1 and other SDOs and international bodies such as ISO, IEC, ITU-T, and industrial fora. Where a potential work item is not being developed by other SDO's, it includes the development of cybersecurity and data protection CEN/CENELEC publications for safeguarding information such as organisational frameworks, management systems, techniques, guidelines, and products and services, including those in support of the EU Digital Single Market. The ZDMP project partner University of Southampton is active in this technical committee.
- **ISO/IEC JTC 1/SC 27** – IT security techniques
  Development of standards for the protection of information and ICT. This includes

generic methods as well as techniques and guidelines to address both security and privacy aspects, such as:

  - Security requirements capture methodology
  - Management of information and ICT security; in particular, 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
  - 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.
- **ISO/IEC JTC 1/SC 32** – Data management and interchange
  Standards for data management within and among local and distributed information systems environments. SC 32 provides enabling technologies to promote harmonisation 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
  - Methods, languages, services, and protocols to structure, organize, and register metadata and other information resources associated with sharing and interoperability, including electronic commerce

- **ISO/IEC JTC 1/SC 38** – Cloud Computing and Distributed Platforms
  Standardisation in the area of Cloud Computing and Distributed Platforms including, but not limited to:

  - Service Oriented Architecture (SOA)
  - Service Level Agreement
  - Interoperability and Portability
  - Data and their Flow Across Devices and Cloud Services

- **ISO/IEC JTC 1/SC 41** – Internet of Things and related technologies
  Standardisation in the area of Internet of Things and related technologies. Serve as a focus and proponent for JTC 1's standardisation programme on the Internet of Things and related technologies, including Sensor Networks and Wearables technologies. Provides guidance to JTC 1, IEC, ISO and other entities developing Internet of Things related applications.
  • **ISO/TC 154** – Process, data elements and documents in commerce, industry, and administration
  International standardisation and registration of business, and administration

processes and supporting data used for information interchange between and within individual organisations and support for standardisation activities in the field of industrial data. Development and maintenance of application specific meta standards for:

- Process specification (in the absence of development by other technical committees)
- Data specification with content
- Forms-layout (paper / electronic)

Development and maintenance of standards for:

- Process identification (in the absence of development by other technical committees)
- Data identification

Maintenance of the EDIFACT-Syntax. The business element content directories are maintained by the United Nations

- **ISO/TC 184** – Automation systems and integration
  Standardisation 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 standardisation include information systems, automation and control systems, and integration technologies.
- **ISO/TC 184/SC 4** – Industrial data
  ISO/TC 184/SC 4 develops and maintains ISO standards that describe and manage industrial product data throughout the life of a product.
- **ISO/TC 184/SC 5** – Interoperability, integration, and architectures for enterprise systems and automation applications
  Standardisation enabling the integration and interoperability of systems, applications, and services for the manufacturing, engineering, and distribution domains of the enterprise and the supply chain. Applying multiple technologies to achieve integration and interoperability.
- **ISO/TC 199** – Safety of machinery
  Standardisation 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.

1.2.4 Cloud and Platforms

Cloud and platforms also belong to a very agile and fast field and are interconnected with smart manufacturing. In the database of the standardisation organisations, few standards can be found yet. The high percentage of specifications (pre-standard like documents) such as DIN SPEC is typical for such an emerging field.

The most relevant standards or specifications are:

Platform:

- **ISO 19119:2016** – Geographic information – Services
- **DIN SPEC 27557:2019** – European Cloud Service Data Protection Controls Catalogue
- **DIN SPEC 91337:2017** – Unified Application Management Interface for Cloud Application Platforms

- **DIN SPEC 91357:2017** – Reference Architecture Model Open Urban Platform (OUP)

Cloud Computing:

- **ISO/IEC 17789:2014** – Information technology – Cloud computing – Reference architecture
- **ISO/IEC 19086-1:2016** – Information technology – Cloud computing – Service level agreement (SLA) framework – Part 1: Overview and concepts
- **DIN SPEC 66286:2014** – Management of Cloud Computing solutions in small and medium enterprises (SME)
- **DIN SPEC 91392:2019** – Marketplace for cloud-based ICT products – Requirements for platform capable ICT services

The most important standardisation committee on international level is:

- **ISO/IEC JTC 1/SC 38** – Cloud Computing and Distributed Platforms
  It conducts standardisation in the areas of Cloud Computing and Distributed Platforms including foundational concepts and technologies, operational issues, and interactions among Cloud Computing systems and with other distributed systems.

1.2.5 Predictive Maintenance

Maintenance is a topic which is well established in standardisation. Nevertheless, maintenance is experiencing substantial changes in connection with smart manufacturing. Reactive and periodic preventative maintenance strategies are increasingly being replaced by predictive ones. In the future, smart, interconnected factories will identify a large proportion of their faults before they occur. This will be enabled by different condition monitoring technologies so that a wide range of data relating to a plant will be captured and analysed.

Most relevant basic standards are:

- **EN 13306:2017** – Maintenance – Maintenance terminology
  Uniform definitions of the concepts underlying all types of maintenance and maintenance management have already been formulated in EN 13306:2018-02, irrespective of the objects or maintenance stakeholders involved.
- **EN 17007:2017** – Maintenance process and associated indicators
  A detailed specification of the essential processes that form part of an overarching maintenance organisation and the associated reciprocal relationships can be found in EN 17007:2017, thereby ensuring that all entities involved in maintenance share the same understanding of the process.

The most important committees regarding ZDMP is:

- **IEC/TC 56** – Dependability
  It prepares international standards in the field of dependability, which is the ability to perform as and when required and is time dependent in application.
- **CEN/TC 319** – Maintenance
  It conducts standardisation in the field of maintenance, as far as generally applicable general standards are concerned.

2 Standardisation Process

2.1 De Jure Standardisation

2.1.1 International Standardisation Work

The International Organization for Standardization (ISO) together with the International Electrotechnical Commission (IEC), are the responsible standardisation organisations on global level. The International Telecommunications Union (ITU) is the United Nation's specialized agency in terms of information and telecommunication technologies.

Many ISO members belong to regional standardisation organisations. ISO has recognized regional standards organisations representing Africa, the Arab countries, the area covered by the Commonwealth of Independent States, Europe, Latin America, the Pacific area, and the South-East Asia nations.

2.1.2 European Standardisation Work

At the European level, following the EC information directive, standardisation work is carried out by the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunication Standards Institute (ETSI).

The European standardisation organisations are associations of national standardisation bodies. Members of CEN and CENELEC are primarily the national standards bodies of EU and EFTA member states, as well as the national standards bodies of other countries intending to become members of the EU or EFTA. Members of ETSI are direct members such as companies, institutes, and services throughout Europe. The responsibility of CEN/CENELEC is the harmonisation of existing national standards in Europe.

The CEN/CENELEC organisational structure has working groups including the General Assembly, Administrative and Technical Boards, as well as Technical Committees (TCs). Those are open to all members and include national delegations presenting agreed positions. European organisations which represent a particular sector may have an observer status. In addition to full members, there are also affiliated standards bodies and associate organisations.

European Standardisation Documents:

At European level, different standardisation documents are available. Each of these represents a different level of consensus:

- The European Standard (EN) aims at developing a normative specification reflecting the current state of technology and knowledge. Every CEN member is obligated to acquire the EN and to withdraw national standards which are in conflict with or duplicate EN standards.
- Other products of European standardisation include European Technical Specifications (CEN/TS) which aim to aid market development and growth for products or methods that are still in the development and/or trial phase, and European Technical Reports (CEN/TR) which provide specifications of a recommendatory and explanatory nature.

- Special specifications, which are developed with the rapid consensus of expert stakeholders (no full consensus needed), can be found in CEN Workshop Agreements (CWA).

The development of an EN and a CWA is explained below. These are the most relevant as potential vehicles for ZDMP orientated standardisation.

Development of a European Standard (EN):

The first step towards the publication of a new standard is the proposal of a new topic by anyone who has a certain demand. This proposal can be submitted to the national standards bodies, which then forwards it to CEN when a European interest is given. If CEN decides to work on the subject, all CEN member countries must stop current national standardisation work regarding the specific subject. A working group responsible for the new work item drafts a first version of the standardisation document. The draft is then distributed to all CEN member states, therefore enabling all European citizens and the standardisation organisations to comment on the draft for usually three months. The CEN member states then vote on accepting the proposed draft. If the enquiry is successful, the EN is published and adopted without changes by all CEN member states.

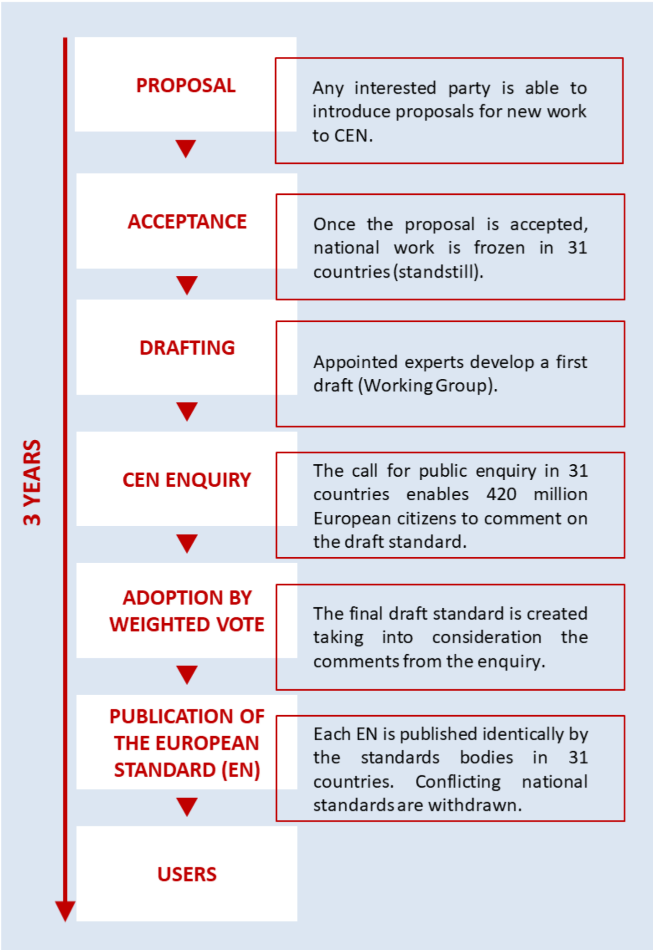


Figure 2: Development of an EN

As well as English, the official languages are French and German. Translations into further languages can be made by the members themselves if needed. All conflicting national standards still in use have to be withdrawn. Due to the involvement of many different stakeholders from every European country which creates well accepted and qualitatively high standards, this process takes around three years from the proposal to the published EN standard.

Development of CEN Workshop Agreement (CWA):

"A CWA is an agreement developed and approved in a CEN workshop; the latter is open to the direct participation of anyone with an interest in the development of the agreement. There is no geographical limit on participation; hence, participants may be from outside Europe. The development of a CWA is fast and flexible, on average between 10-12 months.

A CWA does not have the status of a European Standard. It involves no obligation at national level. A CWA may not conflict with a European Standard; if a conflicting EN is subsequently published, the CWA shall be withdrawn."

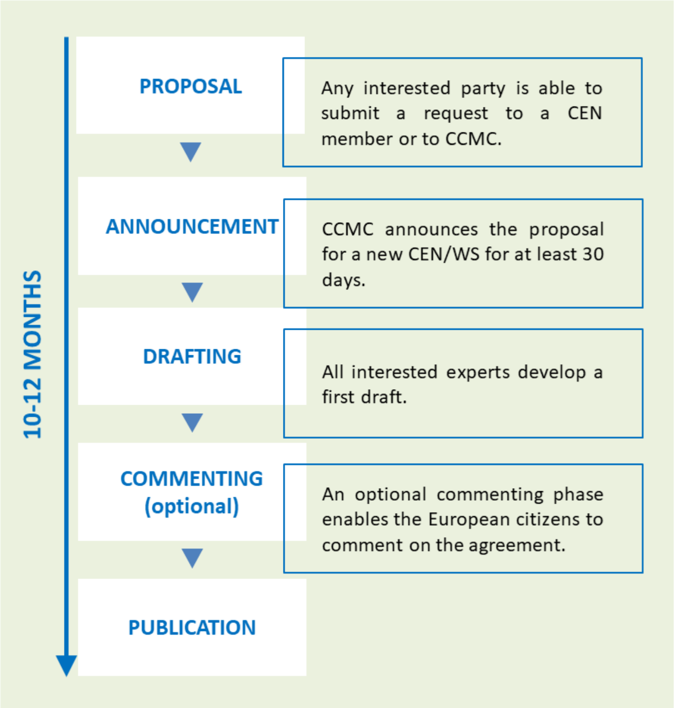


Figure 3: Development of a CWA

CWAs have streamlined processes and quicker adoption procedures which make them a perfect tool for innovations. The development time of a CWA is on average between 10 and 12 months which is also coherent with EU-type projects such as ZDMP.

The CWA development starts with a request of an interested party to a national standardisation body (NSB) as a member of CEN or to the CEN/CENELEC Management Centre (CCMC). The proposer needs to prepare a draft project plan, which describes the objective of the CEN workshop. This can be prepared with the help of an NSB. Subsequently, CCMC announces the proposal for a new CEN workshop for information and transparency reasons in order to inform the public about the ongoing standardisation activity. Comments on the draft project plan can be made and shall be considered in the further development of the document.

During the kick-off meeting for the workshop, the proposed project plan is approved, the workshop formally launched, and the participants who want to work on the CWA are registered. The workshop participants develop draft CWA(s) according to the project plan. The chairperson decides when an agreement on the final text of the CWA is reached amongst the workshop participants. Subsequently, the optional commenting phase begins.

It is open to everyone for at least 60 days. The comments are considered by the workshop members. Afterwards the workshop secretariat submits the approved CWA to the CCMC. CWAs do not have the status of a European Standard and there is no obligation for the national standards bodies to adopt them as national standards. They are checked after 3 years and have a total lifetime of 6 years. The CWA can be understood as a “test-document”. European companies can work with it and if it turns out to be positive, it will likely be used as basis for a new European standard. Since a CWA is created in a rather short time, it is an ideal tool for innovations and research projects. ZDMP expects to achieve one CWA and hopes to achieve three CWAs in total, as it is described in Section 4. This includes a CWA which is envisaged to create in close cooperation with the H2020-projects eFactory and Qu4lity and also linked to Collaboration informal deliverable DX1.

2.1.3 National Standardisation Work

National standards bodies publish national standards and are members of the European and international standards bodies. Examples are ASI, AENOR, UNI, and DIN, the national standards bodies of Austria, Spain, Italy, and Germany. Anyone and any organisation can propose standards and participate in the respective national standards body. All incoming requests are reviewed, and it is then decided by the corresponding committee whether there is a demand in the affiliated industry, whether European or international standardisation activities already exist and on which level the proposed work shall take place. Subjects that are come to European level will trigger a standstill clause at national level as mentioned above. If the document is only on national level, TCs are responsible for the technical input. Those comprise of around 34,500 experts for Germany alone.

TCs are also open for participation of new experts, as they have to include members of each group of interest such as research organisations, industry, and associations. The draft version of a document is released for commenting to the general public for at least 60 days. Everyone who has commented on the draft is invited to a meeting where any objections are discussed. The final document is published afterwards.

2.1.4 Participation in the Standardisation Process

The way of participating in standardisation starts at the national level. Everyone can propose new standardisation topics to the national standards body. Also, during the commenting phase everyone is able to comment on the draft. This is a quite powerful possibility, as the responsible committee has to discuss every comment. Every person who made a comment also has the opportunity to join the meeting to discuss the comment in person. Another way is to personally participate in the national TCs. The different options of participation are illustrated in Figure 4.

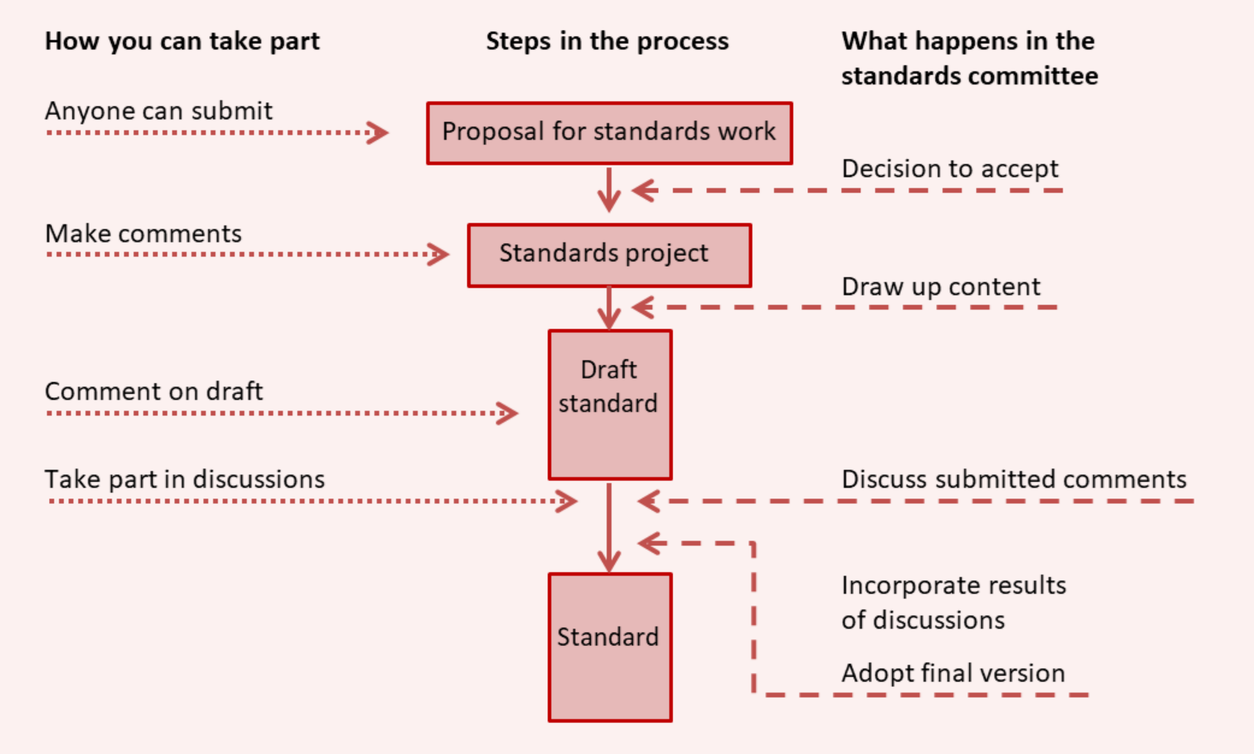


Figure 4: Participation possibilities during the elaboration of an EN standard after [Hal01]

A TC is a technical decision-making body with a title, a scope, and a work program. It manages the preparation of standardisation documents in accordance with the agreed business plan. CEN holds a list containing all TCs. To ensure a high value of standards, the TCs are composed of experts belonging to different interested groups. These groups are, for example, manufacturers, customers, universities, research institutes or authorities. Any expert is welcome to apply for a seat in a national TC. The applications will be examined, depending on the composition, the number of experts already present in the relevant TC, and the regulations of the national standards body. Experts, who are members of national TCs, have the chance to participate in European and international standardisation. They are sent as national delegates to European or international TCs to represent the national interests within a standardisation project.

European associations have the option to participate directly at the European level through liaisons with TCs. Also, research projects may apply for a liaison with a working group (WG), which is a subgroup of a TC. As a liaison organisation, the research projects are observers on a consultative basis and are also informed about standardisation activities.

Most standards are initiated by industry. Other standardisation projects can come from consumers, Small and Medium Enterprises or associations. In addition, the European Commission proposes standards, which are developed to support European legislation.

The choice on how to participate in standardisation and which instrument to use depends strongly on the individual case. In general, for specific issues that need a quick standardisation process a CWA is often the preferred choice. Thus, for innovations CWAs is often the optimal instrument. For guidance in choosing the right instrument, CEN provides a research helpdesk on its website.

2.2 Standardisation in Consortia

The creation of consortium standards (also called de facto standards or industry standards) is typically faster which enables a quick reaction on innovations. Especially in IT related fields such as I4.0, this leads to a distribution of the standardisation activities across a variety of different organisations. Meanwhile, the de jure standardisation organisations offer the creation of consortium standards such as IWA (International Workshop Agreement), CWA (CEN Workshop Agreement), or DIN SPEC (DIN SPECification) themselves.

Just as speed is a big advantage, the lower degree of consensus and the associated lower acceptance compared to de jure standards are significant drawbacks. Consortium standards do not have to be coherent with each other and may even compete with each other. To foster coherence between different consortium standards which creates a higher acceptance of the standards, cooperation between different consortia exist. Nevertheless, the reaction to current developments is so important that many consortium standards are drawn up. A lot of them become widely accepted and many important ones are integrated in the de jure standardisation framework as ISO, IEC, or ITU standards. EU funded projects like COPRAS or StandICT had the task to make standardisation in this area more accessible ie through a guide for research projects on how to utilise standardisation to exploit project results and through a list of relevant standards and standardisers.

Standardisation in consortia has many common elements with de jure standardisation. Nevertheless, each consortium or organisation has its own rules, which differ to a greater or lesser extent from each other. This leads to a wide variety and makes it difficult to gain an overview. Participation in consortia in general requires a membership in the respective organisation which is often for a fee – often the ability to decide comes with a higher fee! For different topics, working groups are set up which are typically open for participation. This is a particularly important fact, as standards require a broad acceptance to be used and a broad acceptance can be generated by a broad participation. Usually, processes are implemented which regulate the decision of developing a new standard, financing the standardisation work, ensuring the formation of a consent during the elaboration of the standard and confirmation of the final version prior to publication. The meetings in which different stakeholders discuss the contents of the standard are held either online or face-to-face, depending on the needs for discussion.

Important consortia and platforms in the field of I4.0 are listed in Figure 5. It shows that ZDMP project partners are active in different consortia, which is an important channel for getting information about the current developments and possibilities for participation in standardisation.

Name	Area	Type	Comments	ZDMP Partners
Consortia and Organisations which develop standards				
IEEE (Institute of Electrical and Electronics Engineers)	Electrical and electronic engineering, telecommuni-cations	International Association, SDO	Developed ie WLAN	VSYS, UNINOVA
W3C (World Wide Web Consortium)	Web	Consortium	Developed HTML, XHTML, XML, RDF, OWL, CSS, SVG	Software AG, UNINOVA
OPC (Object Linking and Embedding for Process Control)	Interoperability, IoT	Consortium	Communication of industrial process data, developed OPC UA	Software AG
oneM2M	IoT, I4.0	Consortium	Focus in interconnectivity between machines	–
OASIS (Organization for the Advancement of Structured Information Standards)	Security, IoT, energy, content technologies, emergency management	Consortium	MQTT standard for leightweight M2M communication	Software AG
OMG (Object Management Group)	Object oriented programming languages	Consortium	Developed object oriented programming languages ie IDL	Software AG, UNINOVA
OSGi (Open Services Gateway initiative)	Modular system and a service platform for Java	Consortium	None	Software AG
JCP (Java Community Process)	Object oriented programming languages	Consortium	None	Software AG
UN/CEFACT (United Nations Centre for Trade Facilitation and Electronic Business)	Interoperability, smart connectivity, I4.0	Consortium (UN Organisation)	Developed the UN/EDIFACT standard for business data exchange (ISO 9735 series)	UNINOVA
Platforms for exchange between relevant companies/institutions				
AIOTI (Alliance for Internet of Things Innovation)	IoT	Platform	Initiated by the European Commission in 2015 to strengthen dialogue between IoT players	UPV, UNINOVA
Platform I4.0	I4.0 (Smart Manufacturing)	Platform	German Platform for a dialogue of I4.0 players and the coordination of activities on a national basis	DIN, Software AG

Figure 5: Important consortia and platforms in the field of I4.0

2.3 Standardisation Tools

2.3.1 CWA – CEN-CENELEC Workshop Agreement

A CWA is a normative document that is developed and approved in a CEN Workshop. It is open to the direct participation of anyone and it is fast and flexible to develop. As it is a specification (vs a standard), a CWA brings no obligation to be adopted at national level. Since it can be used as foundation for the preparation of a full standard, it may be a first step to an ISO or EN standard. A CWA can be used to support a short time to market and is ideal for the application in projects such as ZDMP because of its low preparation time. It fosters the dissemination of innovative solutions and results from research projects and creates trust and acceptance in the market.

The timeframe for the creation is about a year and the lifetime is restricted to 6 years. It requires the application for a CEN Workshop, which has to be approved by CEN-CENELEC. Since many project partners can take part in the workshop, the support of the resulting document can be quite high.

For ZDMP, the creation of CWAs is relevant. The project results can be exploited in a sustainable way, especially when the CWAs are used as a foundation for new full standards. If utilized properly, a CWA can be an effective support for the market entry of ZDMP. ZDMP expects to achieve one CWA and is motivated to create up to three CWAs – See section 3.4.3. Also, within the clustering activities of ZDMP with the projects eFactory and QU4LITY, it is envisaged to create a CWA.

2.3.2 Contribution to Existing Standards

Contribution to existing standards can be made through providing comments in different stages of the standards development as described in Section 2.1.4 and Section 2.2. The proposals are submitted to the respective Committees and if suitable, and possible, a project partner should present the proposed changes in the committee.

Benefits are, that inaccurate or hindering standards can be adjusted which facilitates innovations and that the results are disseminated in a network of experienced experts. The timeframe is mainly determined by the timespan between the meetings of the corresponding committee. Contribution to existing standards requires the monitoring of reviewed standards, consultation of the project partners within the project, and the establishment of contact with the corresponding committee. The proposed changes are treated as a “suggestion” and there is no obligation to incorporate them.

ZDMP is connecting and combining many innovative technologies and is related to many different standards. Therefore, it is likely that during the course of the project possible obstacles or missing requirements will be discovered, especially with regard to the interoperability of different platforms, programs, and devices.

2.3.3 Research of Standards

A research of standards comprises standards from different NSBs, ESOs, ISOs, and further standardisation organisations and results in a list of existing standards for a selected field. It also collects ongoing standardisation activities and lists relevant Technical Bodies. Through the standards research, the project partners get an overview of existing standards and standardisation activities, which also supports the compliance with standards. Standardisation proposals can be aligned with existing standards to avoid inconsistencies which may result in non-technological barriers.

These aspects are especially important for ZDMP. Information about existing standards can be gained through DINs internal databases such as Perinorm, external databases such as the 'standards watch', developed by the H2020 project StandICT, but also by the consultation of internal experts and project partners.

2.3.4 Consultation of TCs

The project manager of a certain “standards” committee is directly contacted to exchange information about the project, possible outcomes which are relevant for the committee, and possibilities to contribute to standardisation. If suitable, as a first result, the project could be presented to the committee. It requires that the project is aware of possible outcomes to discuss possible commonalities and ways to contribute.

This is important for an expedient and sustainable placement of ZDMP project results in standardisation. It supports the incorporation of CWAs produced in connection with ZDMP into standards and submission of contributions to standards at the right time. DIN is a member of all European and many international de jure standardisation committees and in addition has contacts to consortium committees.

2.3.5 Standardisation Workshop

A standardisation workshop is a face-to-face meeting to discuss standardisation ideas, focusing on a specific topic. The framework can be flexible from an internal one to (publicly) open. The main purpose is to identify standardisation potentials and the needs to prepare standardisation activities. A standardisation workshop also provides information on the significance of certain topics and provides an opportunity to inform about relevant standards.

In ZDMP, standardisation workshops are one of the cornerstones for communicating standardisation needs and developing standardisation proposals. This applies both within the project and in cooperation between different projects. A standardisation workshop was already held at the plenary meeting. The results are described in Section 3.4.

3 Standardisation in ZDMP

3.1 General

Standards support three of the main objectives in ZDMP: Extensibility, interoperability, and openness. By compliance with international standards, interoperability is fostered the most. Companies around the world use standardised interfaces, enabling the communication and thus the collaboration between different software packages or whole machines. By supporting the most used interfaces, ZDMP will be able to run in many factories, thus accessing a huge market. ZDMP can thus create an open ecosystem, where developers can offer additional modules to extend the range of functions. A standardised interface of ZDMP with these modules ensures an open and transparent environment, giving developers security whilst minimizing errors.

To utilise standardisation most efficiently, ZDMP sets the following standardisation goals:

- **Compliance**: Monitor the use of standards in the project to foster compliant results
- **Interaction**: Establish contact to relevant groups to receive and provide information
- **Input**: Engage in standardisation to exploit project results

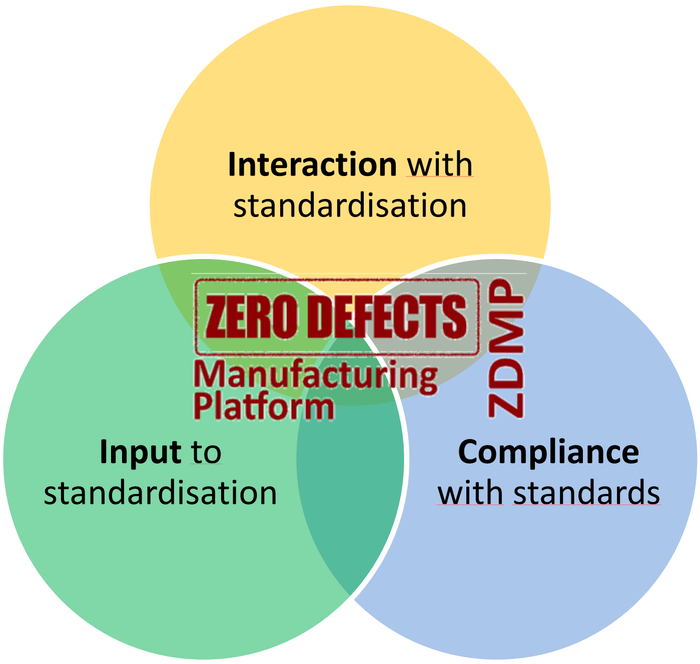


Figure 6: Standardisation goals of ZDMP

3.2 Compliance with Standards

Compliance with standards is very beneficial. The most important benefit is a high interoperability with other platforms, software solutions, and the large number of different sensors and machines. Since ZDMP aims to be interoperable, the compliance with different standards, especially concerning interfaces and communication, is natural. Accordingly, the vf-OS platform, which serves as a basis for ZDMP, and which was also designed to be highly interoperable, complies with relevant standards.

To support ZDMP's goals of being interoperable and expandable, it is important that the project partners have knowledge about additional standards which could be relevant. As a first step, DIN was introduced as contact point for standards in the plenary meeting, highlighting the benefits of standards and standardisation. Subsequently, using information from the project partners, DIN Smart Manufacturing specialists, ASI (Austrian Standards International), and eFactory experts (a parallel funded project, dealing with I4.0), a list of standards was created (the full list is available Annex C).

To inform the consortium about current standards and to monitor the use of standards, the consortium had to rate every standard in the list to be 0 – "not relevant", 1 – "maybe relevant", 2 – "highly relevant" or 3 – "will be used". The project partners responsible for architecture components were also asked to provide their supported or used standards. For each standard, the respective components can be found in the "architecture component" column of the table below. The list will be extended and used to monitor the use of standards throughout the project.
→ See Recommendations Section 4, work item: A6.4-15 and A6.4-16.

The 20 best rated standards are presented in Figure 7.Components, where the usage of a specific standard is still under discussion, are marked with an asterisk (*). In some case the cell is marked 'None Currently', but the entry is left in since it is believed they there may still be some relationship and/or it is more general such as those being related to architecture. However, it is a convenient list to maintain this information.

Area	Committee	Document Identifier	Title	Rating	Architecture Component
Message Exchange	ISO/IEC JTC 1	ISO/IEC 21778:2017	Information technology – The JSON data interchange syntax	1.8	Digital twin, application run-time, inter-platform interoperability, data acquisition, services and message bus, ai-analytics designer, ai-analytics runtime, marketplace, storage, human collaboration
Message Exchange	ISO/IEC JTC 1	ISO/IEC 20922:2016	Information technology – Message Queuing Telemetry Transport (MQTT)	1.6	Application run-time, inter-platform interoperability, data acquisition, services, and message bus
Data Inter-operability	IEC/TC 65/SC 65E	IEC 62541 series [Under development]	OPC unified architecture – All Parts	1.6	Data acquisition*, portal*, services and message bus

IoT, Device Integration	IEC/TC 65	IEC PAS 63 088:2017	Smart manufacturing – Reference architecture model industry 4.0 (RAMI4.0)	1.5	Digital twin, process optimization run-time
Message Exchange	ISO/IEC JTC 1	ISO/IEC 19 464:2014	Information technology – Advanced Message Queuing Protocol (AMQP)	1.4	Process optimization run-time, application run-time, inter-platform interoperability
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC NP TR 301 64 [Under development]	Internet of things (IoT) – Edge Computing	1.4	Distributed computing
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC 21 823-1:2019	Internet of things (IoT) – Interoperability for internet of things – Part 1: Framework	1.3	Data acquisition*
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC 30 141:2018	Internet of Things (IoT) – Reference Architecture	1.2	None Currently
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC NP 30161 [Under development]	Internet of Things (IoT) – Requirements of IoT data exchange platform for various IoT services	1.2	Application runtime*
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC NP 30162 [Under development]	Internet of Things (IoT) – Compatibility requirements and model for devices within industrial IoT systems	1.2	Applications builder*
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC NP 30165 [Under development]	Internet of Things (IoT) – Real-time IoT framework	1.2	Process optimization run-time, process assurance run-time
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC NP 30147 [Under development]	Information technology – Internet of things – Methodology for trustworthiness of IoT system/service	1.1	None Currently
IoT Architecture	IEEE	IEEE P241 3:2019	Architectural Framework for the Internet of Things (IoT)	1.1	None Currently
Cloud Computing	ISO/IEC JTC 1/ SC 38	ISO/IEC 17 788:2014	Information technology – Cloud computing – Overview and vocabulary	1.1	Autonomous computing, distributed computing, storage
IoT, Device Integration	ISO/IEC JTC 1/ SC 41	ISO/IEC NP 30149 [Under development]	Internet of things (IoT) – Trustworthiness framework	1.1	Secure communication, secure authentication/ authorisation, security designer*
IoT, Device Integration	IEC/TC 65/ SC 65B	IEC 61499-4:2013	Function blocks – Part 4: Rules for compliance profiles	1.0	None Currently
Information Security	IEC/TC 65	IEC 62443 series	Security for industrial automation and control systems	1.0	Secure installation, secure communication, secure authentication/authorisation

Information Security	ISO/IEC JTC 1/ SC 27	ISO/IEC 27 017:2015	Security techniques – Code of practice for information security controls based on ISO/IEC 27002 for cloud services	1.0	None Currently
Safety of machinery	ISO/TC 199	ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction	1.0	
Information Security	ISO/IEC JTC 1/ SC 27	ISO/IEC 27002:2013	Information technology - Security techniques - Code of practice for information security controls	1.0	

Figure 7: Most important standards in ZDMP

The rating of the standards list confirmed that interoperability is most important for ZDMP. Best rated standards are the JSON data interchange syntax, the Message Queuing Telemetry Transport (MQTT), and the OPC UA series in the areas data exchange and data interoperability. This is in line with the development that whole industries (eg the woodworking industry) aim to use the OPC UA standard as a common interface.

To keep compliant with current standards, it is also important to monitor the release or reworking of standards relevant to ZDMP. This will be ensured by periodically standards searches using DIN tools and by querying project partners which are members in relevant consortia as OPC (DIN), OASIS/MQTT (Software AG), or IEEE (VSYS). The full list of standards is presented in Annex 3.

3.3 Interaction with Standardisation

Interaction with standardisation committees is important to get relevant information about the latest developments and to increase the network in relevant fields. A contact to one or more experts participating in a standards committee is beneficial for the initiation of a new standard or specification. Also, platforms such as AIOTI, the CEN-CENELEC-ETSI Coordination Group on Smart Manufacturing, or the "Plattform Industrie 4.0" give the opportunity to increase the network of the project and to connect with further experts, active in standardisation.

Therefore, ZDMP will establish contact and engage in at least one of the mentioned platforms through its project partners. The engagement in the platforms will also be used to advertise planned standardisation activities and to gain experts for these activities. In this regard, a good contact to the Zero Defects Cluster is crucial. The Zero Defects Cluster is a platform, founded by different previous H2020 Zero Defects projects. Contact to the Cluster has already been established.

Direct interaction with certain standardisation committees will also be established by DIN, which is member in a large number of ISO and joint ISO/IEC committees. It is a promising strategy, that a project partner introduces the national mirror committee to ZDMP and planned standardisation activities to give input into standardisation and to gain experts for future collaboration. If the project results lead to standardisation activities involving input into consortia, the contacts and expertise of the project partners SAG, HSD, CET, and UOS-ITI, who are active in the most important consortia can be used.
→ See Recommendations Section 4, work item: A6.4-17 and A6.4-18.

3.4 Input into Standardisation

Providing input to standardisation is a good way to sustainably exploit project results. Possible ways are to provide input are to comment on standards drafts, to present certain ideas or proposed changes to relevant committees, and to initiate the creation of standardisation documents. The first two options require monitoring of the activities in the relevant committees to wait for the right time slot. The third option can be conducted at any time. The most prominent documents are official standards, but to initiate and accompany its creation is in general not suitable for research projects which are naturally limited in time. A more suitable way is to create a specification ie a CEN Workshop Agreement (CWA) which needs around 12 months from the initiation to its completion. When the CWA is completed, it can be used to initiate an official standard. If the relevant committee votes to create a full standard on the basis of the CWA, the standard will be mainly created after the project end under the responsibility of the relevant committee.

A basis for input to standardisation is the identification of standardisation needs. This can be performed by monitoring and evaluating the project results and by collecting ideas in common workshops and also in exchange with the project coordinator and project partners throughout the project lifetime. Especially in ZDMP, also common standardisation gaps of eFactory or the Zero Defects cluster with ZDMP can be identified. Based on the identified gaps and ideas, a detailed standards research will be undertaken, to check if standards for the specific purpose already exist. If the idea or the project results are suitable for standardisation and if the ZDMP project partners are motivated to create a specification, standardisation activities will be initiated.

3.4.1 Standardisation Workshop

A standardisation workshop has been conducted on the 2nd ZDMP plenary meeting to identify standardisation gaps and to collect ideas and needs for standards. The project partners were asked to develop ideas for new standards in groups of 2-3 people and to think of different types of standards in different topics.

The different types of standards were:

- Interface standards
- Product standards
- Service standards
- Process standards
- Methodology standards
- Test methods standards
- Terminology standards

The topics were for example:

- Smart Manufacturing
- Predictive Maintenance
- Condition Monitoring
- Zero Defects

Each group had the task to stick cards with headlines on the wall and to present their group idea in a few sentences. Subsequently, the project partners rated the different ideas by sticking dots on the cards. Figure 8 shows a picture of the developed ideas and the voting results. Ideas about data definition and exchange were grouped. The biggest need was identified concerning standards for Data (37 points), followed by terminology

(15 points) and a Zero Defects process (11 points). Parallel to the group work, the project partners were asked to send additional ideas via mail, to consider every relevant idea. Hereafter, each idea will be briefly explained.

Figure 8: Results of standardisation workshop

Data Exchange (37 points):

The platform receives different data from a variety of different sensors and machines. This raises the need for a unified data exchange format. In the focus are:

- Ontologies
- Transformation
- Interface
- Access
- Format
- Structure
- Definition

(to be considered in Section 4, work item: A6.4-14)

Terminology (15 points):

Zero Defects specific terms are very scarcely or not defined. The idea is to set up a terminology standard, including all relevant definitions in the field of Zero Defects Manufacturing. A terminology standard will facilitate the exchange of information between different companies. (to be considered in Section 4, work item: A6.4-06)

Further details: The Zero Defects cluster already prepared a glossary, which can be used and extended. Also, the ZDMP Glossary will be used.

Zero Defects Process (11 points):

A process to transform a manufacturing unit into a Zero Defects manufacturing unit is not defined yet. It could support factories in reaching a certain quality standard with the use of digital manufacturing tools. In connection with processes, the standard BPMN 2.0 should be considered.

IOT Gateway (9 points):

An IOT Gateway is a software platform which works with multiple inputs and sends out standardised output to be further processed by the platform. In this context the gateway including the used output format could be standardised.

Predictive Maintenance Workflow (5 points):

The aim of such a workflow is to make different use cases for predictive maintenance comparable. It has to be applicable to several scenarios in industry.

Tooling Performance (1 point):

To enable predictive maintenance, the tooling performance of several tools needs to be monitored in a standardised way. By analysing comparable data, mathematical models can predict errors or failures.

Machine Performance (mail):

The aim is to characterise whether a multi-sensor machine meets the specs of the manufacturer as far as it can be analysed by a comparison between a basic profile of the manufacturer and a profile constantly measured by the client. The data of the profile should be compressed using fractal techniques to make it applicable to (well established) image processing techniques for comparison.

This way the supplier of the equipment can provide a standardized touchstone 'document' that the customer can compare to their own performance characterisation and determine if and how their tooling is working as expected. The steps to be conducted are:

- Characterize machine – determine what is 'normal' this gives a 'standardized character document'.
- Customer characterizes their machine using the 'standardized character document' – which gives their own character document.
- Comparison tools allow customers to know if their tool (and by how much) it matches the original.

The idea is to standardise both format and process for this characterisation.

Standardisation for Application Description (mail):

The aim is to define a unified description of applications (the description itself and how it should be described). (to be considered in Section 4, work item: A6.4-10)

Test Method for Machine Learning Systems (mail):

Many machine learning systems are trained offline, "frozen", tested, and then implemented in the target system. Testing of such systems is performed through a process called "cross-validation". This splits data into two groups; one group is used for training and the other one for evaluation. However, this can only be based on the available data. Experience has shown that some machine learning systems (especially "deep learning") can be sensitive to small variations in the input data, so that a small change/level of noise could lead to substantially different results. Methods to evaluate these properties are not yet established. The situation is even more interesting for machine learning systems that are trained online. They will change their behaviour based on the input data that they receive during operation.

Properties of the Apps (mail):

The idea is to define requirements for the apps, connecting the supply chain. The underlying questions for this idea are: How is security enforced? Who owns the data? Who manages the app itself? (to be considered in Section 4, work item: A6.4-10)

Building Information Modelling:

Input may also be provided to the emerging field off building information modelling (BIM), to incorporate Zero Defects measures into future BIM standards.

Comparative Study of Reference Models:

In ZDMP Task 2.4, a comparative study of I4.0 reference models was conducted. An idea could be to make the results of this study or parts of it available as a standardisation document.

Further Ideas (mail):

- Standard APIs for ZD services
- Standard Data formats for ZD related data
- Catalogue/Template to despite ZD products
- Definition of time scale for data exchange: "real-time" means different time scales depending on the application

3.4.2 Clustering

In a clustering meeting between the projects ZDMP and eFactory, possible common standardisation gaps were discussed. Through the participation of ASI (Austrian Standards International), which is a project partner of eFactory, the idea of joint standardisation activities and the motivation to create joint standardisation documents, have been deeply anchored in both the projects.

It is envisaged, to create a joint CWA. (Section 4, work items: A6.4-07 to A6.4-10) The two projects have similarities in the I4.0 field, especially digital platforms, and interoperability between a variety of devices and a variety of software solutions. The differences between the two projects are in the specific focus areas. ZDMP focuses on Zero Defects while eFactory focuses on lot size one. Therefore, common standardisation activities will be conducted concerning platforms or data exchange. For example, one area that could be explored is a specification about the requirements of apps to run on the various platforms. Also, a specification about the proper handling of different data formats could be possible or a manifest specification such as that hinted at in the section above.

In future clustering activities, also the 3rd platform project, Qu4lity, will be reviewed. Since the similarities lie in the field of Zero Defects manufacturing, a participation in ZDMP standardisation activities and the creation of further common activities, also within the ZD Cluster can be possible. However, to date this is not perceived as a Qu4lity priority since they have minimal standardisation goals in their project.

The next common activity between the three projects ZDMP, eFactory, and Qu4lity to foster standardisation activities and the interaction with standardisation stakeholders is a joint booth at the CEN-CENELEC conference 'Boosting innovation through standards' in Brussels in November 2019.

3.4.3 Major Needs and Most Promising ideas

App Requirements:

An important need is to standardise requirements and interfaces for apps, which run on platforms like ZDMP. These can be in regard to security related issues, as well as the exact specification of interfaces. The involvement of different stakeholders ensures a well-tuned set of requirements. A conceivable cooperation with the projects eFactory and Qu4lity within the framework of a CWA would ensure uniform conditions and, if possible, promote interoperability of apps between the platforms. Further platform projects (and others) related to Human Centeredness in factories and the Circular economy could also be considered to be added to the cluster if they find it beneficial.
→ See Recommendations Section 4, to be involved in work item: A6.4-10.

Comparative Study of Reference Models:

The comparative study of I4.0 reference models, conducted in ZDMP Task 2.4 will be submitted to the platform AIOTI, or the CEN-CENELEC-ETSI Coordination Group on Smart Manufacturing and presented upon interest.
→ See Recommendations Section 4, work item: A6.4-01.

Data Exchange:

The project partners have a high need for standards in connection with data exchange. This covers many different aspects, such as:

- Ontology
- Transformation
- Interface
- Access
- Format
- Structure
- Definition

This is not to be interpreted as a need for new standards, as in this field there exist prominent standards such as OPC UA or ETSI TS 118 112 V2.0.0 (2016-09) – oneM2M – Base Ontology. It is a need for guidance on the most suitable and most common standards and common set of applied standards within ZDMP and between different platforms to foster interoperability and thus to reach a faster market access.

Specific needs will be addressed in a common workshop to specify the common needs and to decide upon preparation for a project plan for a CWA on Manufacturing Platform Data Exchange. It would be a good opportunity to involve eFactory and Qu4lity in the envisaged conduction of the CEN-CENELEC Workshop.
→ See Recommendations Section 4, work item: A6.4-14.

Terminology:

Zero Defects specific terms are very scarcely or not defined in standards. The idea is to set up a terminology standard, including all relevant definitions in the field of Zero Defects Manufacturing and to make use of a glossary, already prepared by the Zero Defects cluster, founded by preceding Zero Defects projects. The contact to the Zero Defects cluster is already established. A terminology standard will facilitate the exchange of information between all involved stakeholders and simplify communication. The procedural details of the creation of a CWA will be discussed with the project partners in the next plenary meeting. An involvement of experts belonging to the Zero Defects Cluster and to

Qu4lity will be beneficial and is therefore envisaged.
→ See Recommendations Section 4, work item: A6.4-06.

Building Information Modelling:

Building information modelling (BIM) is an emerging topic which connects the building sector with I4.0 techniques. The main element is a detailed digital representation of the building in order to simplify decisions during the planning, but also to keep track of the current status during the construction works. A connection of the zApp4.13 – zMaterialTracker (ZDMP Deliverable 2.3) with common BIM software through a common interface would support the application of ZDMP in the building sector.
→ See Recommendations Section 4, work item: A6.4-02.

Therefore, it is envisaged to present the zMaterialTracker to relevant committees such as the CEN/TC 442 – Building Information Modelling (BIM) or one or two of its national mirror groups.

4 Recommendations

Note that ASI, Austrian Standards, is not a ZDMP project partner but is playing the equivalent role of DIN in the eFactory project and where both projects are trying to work closely together on standards and other matters.

Identifier	Dates	Action	Partners
Contribution			
A6.4-01	M10-M12	**Contribution to I4.0 reference models** DIN establishes contact and submits comparative study of reference models to AIOTI or the CEN-CENELEC-ETSI Coordination Group	**DIN**, UPV
A6.4-02	M13-M15	**Contribution to BIM** DIN presents zApp 4.13 – zMaterialTracker to the German mirror group of CEN/TC 442.	**DIN**, users
A6.4-03	M30-M32	**Use case standardisation workshop** After the pilot implementation (WP9 and WP10) has started, a standardisation workshop is conducted to detect if further project results are highly relevant for standardisation.	**DIN**, all project partners
CWA on ZD Terminology			
A6.4-04	M11-M12	**Establishment of contact to relevant committees** The standardisation idea is presented to relevant experts of one or more national mirror groups	**DIN**
A6.4-05	M12-M14	**Preparation of project plan** Creation of a project plan and application for a CEN Workshop with the support of DIN	**DIN,** relevant project partners
A6.4-06	M17-M26	**Conduction of CEN WS** Upon acceptance of project plan by CEN/CENELEC, conduction of the CEN Workshop, involving partners from the ZD cluster and Qu4lity	**DIN,** relevant project partners
CWA on App Requirements			
A6.4-07	M12-M14	**Specification of common basis** Further compilation of common standards which are used by the projects eFactory and ZDMP	**DIN, ASI**
A6.4-08	M14-M16	**Sharpening of topic** Conduction of an active exchange to sharpen the need for a common specification of requirements for apps, running on ZDMP or eFactory. Identification of additional standardisation needs and gaps in the used standards.	**DIN, ASI**, ZDMP, eFactory
A6.4-09	M17-M19	**Preparation of project plan** If one or more suitable topics are identified, creation of a project plan for a CWA by the projects eFactory and ZDMP with the support of ASI and DIN**.**	**DIN, ASI**, relevant project partners
A6.4-10	M22-M31	**Conduction of CEN WS** If the project plan is accepted by CEN/CENELEC, conduction of the CEN Workshop	**DIN, ASI**, relevant project partners
CWA on Data Exchange Guidance			
A6.4-11	M14-M16	**Sharpening of topic** A workshop is conducted, and project partners are consulted to sharpen the topic and the intended content	**DIN,** relevant project partners

Identifier	Dates	Action	Partners
A6.4-12	M16-M17	**Establishment of contact to relevant committees** The standardisation idea is presented to relevant experts of one or more national mirror groups	**DIN**
A6.4-13	M17-M18	**Preparation of project plan** Creation of a project plan and application for a CEN Workshop with the support of DIN	**DIN,** relevant project partners
A6.4-14	M21-M30	**Conduction of CEN WS** Upon acceptance of project plan by CEN/CENELEC, conduction of the CEN Workshop, involving partners from eFactory and Qu4lity	**DIN,** relevant project partners
Compliance			
A6.4-15	M12, M17, M23, M29, M35, M41	**Update standards list** Check databases for new or updated standards and poll project partners	**DIN,** relevant project partners
A6.4-16	M17, M29, M41	**Monitoring of standards use** The project partners answer a questionnaire about the used standards	**DIN,** all project partners
Interaction			
A6.4-17	M07-M12	**Connect with platforms** Apply for membership in CEN-CENELEC-ETSI Coordination Group on Smart Manufacturing, connect with 'Plattform Industrie 4.0' and with AIOTI	**DIN,** relevant project partners
A6.4-18	M36-M48	**Disseminate results** Project partners approach 3 different national mirror groups of relevant committees to present results (CWA, further ideas) of ZDMP	**DIN,** relevant project partners

Figure 9: Recommended action plan for standardisation in ZDMP

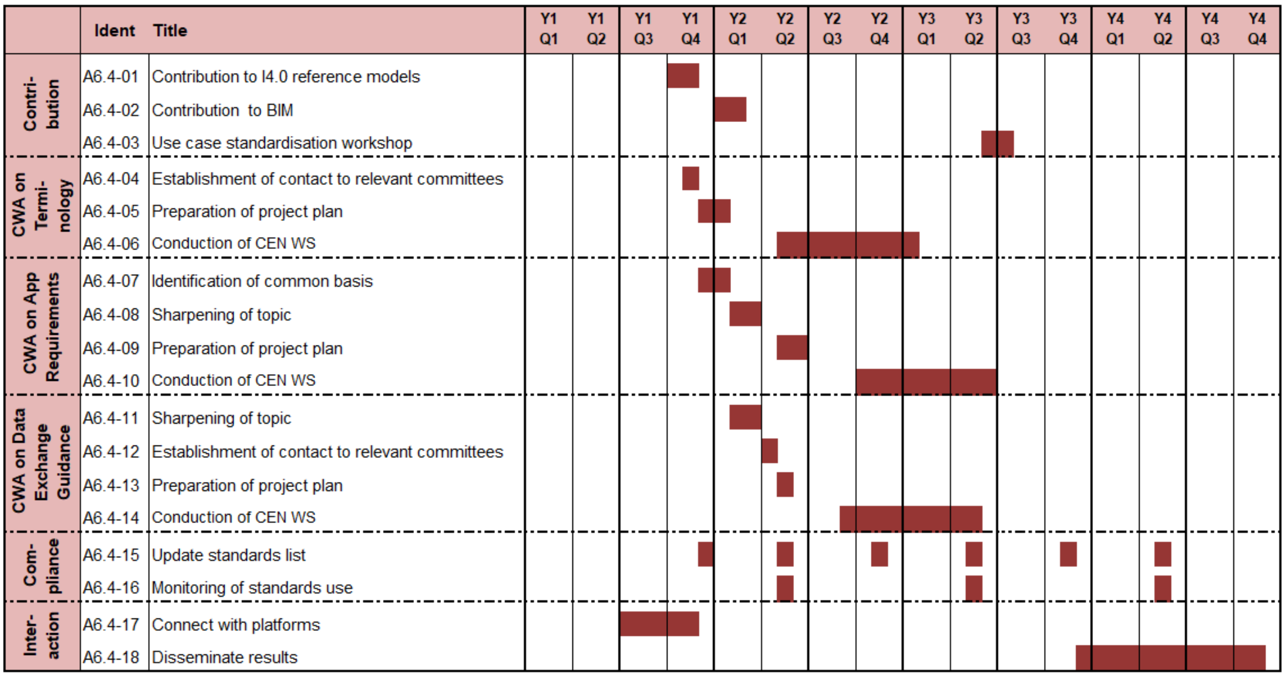


Figure 10: Gantt chart for recommended actions

5 Conclusion

The field of Zero Defects manufacturing is highly interwoven with I4.0 (Smart Manufacturing), which is an exceptionally large and agile field. This also applies to the standardisation perspective. Many de jure and de facto standards are already established, which enables a certain degree of interoperability between machines and platforms. Nevertheless, regarding Zero Defects, only a few standards exist.

By conducting a standardisation workshop, it was possible to discover the needs of ZDMP from a general perspective in the first place. The results of the workshop form a basis for the successful conduction of the present task. The needs mainly concern interoperability and terminology, but also many different topics as the definition of requirements for future apps, running on ZDMP. The rating and complementation of a standards list sensitized the project partners for the present standardisation landscape and serves as a basis for the ongoing monitoring of the compliance of ZDMP with standards. Some project partners are already connected and experienced with standardisation which includes both de jure standardisation and standardisation in consortia.

Mainly in the upcoming one and half years, the creation of a CWA will be coordinated and executed. Including cooperation with eFactory, ZDMP hopes to create up to three CWAs in total. Additionally, further interaction with standardisation will be established by DIN and the project partners. Overall, the project partners are very motivated to engage in standardisation activities, which is a good foundation for the present task and the connected exploitation of project results.

Annex A: History

Document History	
Versions	V0.1-0.1.5: • General structure, initial Contents: Standards research and standardisation procedure V0.1.6-1.8: • Standards list added, standards research extended V.0.2.0: • Standardisation tools, compliance, interaction, input, and conclusion added V.0.2.1: • Standardisation tools and recommendations added, first corrections V1.0.0: • Version ready for first review V1.0.1: • Issues corrected due to 1st reviewer's comments. No major issues. • Gantt chart added V 1.0.2 • Architecture components added and 2nd reviewer version V 1.0.3 • Architecture component updated V 1.0.4 • Version for final reviewer V 1.0.4 • Review Adjustments V 1.0.6 • EU Submitted Version
Contributions	DIN: • Christian Grunewald – Entire document • Stefanie Müller – Standards list, standards research, review SAG: • Marc Dorchain – 1st review, Assignment of architecture components to standards CET: • Juan Pardo – 2nd review, Assignment of architecture components to standards ICE: • Stuart Campbell – Final review • Philip Usher – Assignment of architecture components to standards ASC: • Tim Dellas – Assignment of architecture components to standards SIVECO: • Mircea Vasile – Assignment of architecture components to standards PRO: • Christian Eitzinger – Assignment of architecture components to standards IKER: • Eduardo Saiz – Assignment of architecture components to standards UOS–ITI: • Zlatko Zlatev – Assignment of architecture components to standards • Juri Papay – Assignment of architecture components to standards All partners: • Standards Rating

Annex B: References

[Hal01] S. Hallscheidt, N. Adomeit, T. Manske, J. U. Hopf, An Introduction to standardization, Beuth, Berlin, 2016

Annex C: List of ZDMP Related Standards

The list of ZDMP related standards is based on standard researches of ASI, DIN, and the H2020 project StandICT, including a consultation of DIN internal I4.0 experts and experts from the projects ZDMP and eFactory. The rating was conducted by the ZDMP project partners to monitor the use and importance of relevant standards. The column architecture component contains the components which are intended to comply with or to make use of a specific standard.

Components, where the usage of a specific standard is still under discussion, are marked with an asterisk (*). In some case the cell is marked 'None Currently', but the entry is left in since it is believed they there may still be some relationship and/or it is more general such as those being related to architecture. However, it is a convenient list to maintain this information. The list is also used to identify possible standardisation gaps and to identify common interests for common standardisation activities with H2020 platform project eFactory or the platform Cluster initiated by ZDMP. The list will be extended during the project lifetime.

IoT, Device Integration				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
IEC/TC 65 Industrial-process measurement and control	IEC PAS 63088:2017	Smart manufacturing – Reference architecture model industry 4.0 (RAMI4.0)	1.5	Digital twin, process optimization run-time
IEC/TC 65/SC 65B Elements of systems	IEC 61499-1:2012	Function blocks – Part 1: Architecture	0.9	Process quality and optimisation designer
	IEC 61499-2:2012	Function blocks – Part 2: Software tool requirements	0.9	Process quality and optimisation designer
	IEC 61499-4:2013	Function blocks – Part 4: Rules for compliance profiles	1.0	None Currently
ISO/IEC JTC 1/SC 41 Internet of Things and related technologies	ISO/IEC 21823-1:2019	Internet of things (IoT) – Interoperability for internet of things systems – Part 1: Framework	1.3	Data acquisition*
	ISO/IEC 30141:2018	Internet of Things (IoT) – Reference Architecture	1.2	Data acquisition*
	ISO/IEC NP 30144 [Under development]	Information technology – Sensor network system architecture for power substations	0.6	Data acquisition*
	ISO/IEC NP 30147 [Under development]	Information technology – Internet of things – Methodology for trustworthiness of IoT system/service	1.1	Secure communication,
	ISO/IEC NP 30149 [Under development]	Internet of things (IoT) – Trustworthiness framework	1.1	Secure communication, secure authentication/authorisation, security designer*

	ISO/IEC NP 30161 [Under development]	Internet of Things (IoT) – Requirements of IoT data exchange platform for various IoT services	1.2	Application runtime*
	ISO/IEC NP 30162 [Under development]	Internet of Things (IoT) – Compatibility requirements and model for devices within industrial IoT systems	1.2	Applications builder*
	ISO/IEC NP 30163 [Under development]	Internet of Things (IoT) – System requirements of IoT/SN technology-based integrated platform for chattel asset monitoring supporting financial services	0.5	None Currently
	ISO/IEC NP TR 30164 [Under development]	Internet of things (IoT) – Edge Computing	1.4	Distributed computing
	ISO/IEC NP 30165 [Under development]	Internet of Things (IoT) – Real-time IoT framework	1.2	Process optimization run-time process assurance run-time
ISO/TC 184 Automation systems and integration	IEC 62264-1:2013	Enterprise-control system integration – Part 1: Models and terminology	0.9	Digital twin
	IEC 62264-2:2013	Enterprise-control system integration – Part 2: Objects and attributes for enterprise-control system integration	0.9	Digital twin
	IEC 62264-3:2016	Enterprise-control system integration – Part 3: Activity models of manufacturing operations management	0.9	Digital twin
	IEC 62264-4:2015	Enterprise-control system integration – Part 4: Objects and attributes for manufacturing operations management integration	0.9	Digital twin
	IEC 62264-5:2016	Enterprise-control system integration – Part 5: Business to manufacturing transactions	0.8	Digital twin

Data Interoperability, OPC, Industry 4.0

Committee	Document Identifier	Title	Rating	Architecture Component
IEC/TC 65 Industrial-process measurement and control	IEC 62890 ED1 [Under development]	Life-cycle management for systems and products used in industrial-process measurement, control, and automation	0.7	Orchestration designer*
	IEC PAS 63088:2017	Smart manufacturing – Reference architecture	1.5	Digital twin

		model industry 4.0 (RAMI4.0)		
OPC Foundation and IEC/TC 65/SC 65E Devices and integration in enterprise systems	IEC/TR 62541-1 ED3 [Under development]	OPC unified architecture – Part 1: Overview and concepts	1.5	Data acquisition*
	IEC/TR 62541-2 ED3 [Under development]	OPC unified architecture – Part 2: Security Model	1.5	Data acquisition*, portal*
	IEC 62541-3 ED3 [Under development]	OPC unified architecture – Part 3: Address Space Model	1.5	Services and message bus
	IEC 62541-4 ED3 [Under development]	OPC Unified Architecture – Part 4: Services	1.6	Services and message bus
	IEC 62541-5 ED3 [Under development]	OPC Unified Architecture – Part 5: Information Model	1.5	Services and message bus
	IEC 62541-6 ED3 [Under development]	OPC unified architecture – Part 6: Mappings	1.5	Services and message bus
	IEC 62541-7 ED3 [Under development]	OPC unified architecture – Part 7: Profiles	1.5	Services and message bus
	IEC 62541-8 ED3 [Under development]	OPC Unified Architecture – Part 8: Data Access	1.6	Services and message bus
	IEC 62541-9 ED3 [Under development]	OPC Unified Architecture – Part 9: Alarms and conditions	1.5	Services and message bus
	IEC 62541-10 ED3 [Under development]	OPC Unified Architecture – Part 10: Programs	1.6	Services and message bus
ISO/TC 154 Processes, data elements and documents in commerce, industry, and administration	ISO 9735 series	Electronic data interchange for administration, commerce, and transport (EDIFACT)		Data Harmonisation Design and Runtime
DIN German Institute for Standardization	DIN SPEC 16592:2016	Combining OPC Unified Architecture and Automation Mark-up Language	0.6	Application runtime*

Maintenance

Committee	Document Identifier	Title	Rating	Architecture Component
IEC/TC 56 Reliability and maintainability	IEC 62402 ED2 [Under development]	Obsolescence management – Application guide	0.6	None Currently
CEN/TC 319 Maintenance	EN 13306:2017	Maintenance – Maintenance terminology	0.8	Prediction and optimisation runtime
	EN 16646:2014	Maintenance – Maintenance within physical asset management	0.8	None Currently

	EN 17007:2017	Maintenance process and associated indicators	0.8	None Currently
ISO/TC 108 Mechanical vibration, shock, and condition monitoring	ISO 13372:2012	Condition monitoring and diagnostics of machines. Vocabulary	–	Prediction and optimisation runtime
	ISO 13381-1:2015	Condition monitoring and diagnostics of machines - Prognostics - Part 1: General guidelines	-	Prediction and optimisation runtime
Messaging, Message Exchange				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
ISO/IEC JTC 1 Information Technology	ISO/IEC 19464:2014	Information technology – Advanced Message Queuing Protocol (AMQP)	1.4	Process optimization run-time, application run-time (sdaim), inter-platform interoperability (sdaim)
	ISO/IEC 19845:2015	Information technology – Universal Business Language Version 2.1 (UBL v2.2)	0.6	Data Harmonisation Design and Runtime
	ISO/IEC 20922:2016	Information technology – Message Queuing Telemetry Transport (MQTT)	1.6	Application run-time (sdaim), inter-platform interoperability (sdaim), data acquisition, services, and message bus
	ISO/IEC 21778:2017	Information technology – The JSON data interchange syntax	1.8	Digital twin, application run-time (sdaim), inter-platform interoperability (sdaim), data acquisition, services and message bus, ai-analytics designer, ai-analytics runtime, marketplace, storage, human collaboration
	ISO/IEC 30118-1:2018	Information technology – Open Connectivity Foundation (OCF) Specification – Part 1: Core specification	0.6	None Currently
Industrial Automation Systems, Product Catalogues				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**

IEC/TC 2 Rotating machinery	IEC 60034 series [Under development]	Rotating electrical machines	1.7	None Currently
IEC/TC 22/SC 22G Adjustable speed electric drive systems incorporating semiconductor power converters	IEC 61800 series [Under development]	Adjustable speed electrical power drive systems	1.5	None Currently
IEC/TC 65/SC 65B Measurement and control devices	IEC 61131 series	Programmable controllers	0.7	None Currently
IEC/TC 65/SC 65E Devices and integration in enterprise systems	IEC 62714 series [Under development]	Engineering data exchange format for use in industrial automation systems engineering – Automation mark-up language	0.8	None Currently
ISO/TC 184 Automation systems and integration	IEC 62264 series	Enterprise-control system integration	0.6	None Currently
	ISO 10303-236:2006	Industrial automation systems and integration – Product data representation and exchange – Part 236: Application protocol: Furniture catalogue and interior design – and Application modules	0.4	None Currently
	ISO 20534:2018	Industrial automation systems and integration – Formal semantic models for the configuration of global production networks	0.5	None Currently
	ISO/CD 23247 series [Under development]	Digital Twin manufacturing framework	0.7	Digital twin, process assurance run-time
Enterprise Systems, Interoperability, Integration				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
ISO/TC 184 Automation systems and integration	ISO/DIS 22549-1:2019 [Under development]	Automation systems and integration – Assessment on convergence of informatization and industrialization for industrial enterprises – Part 1: Framework and reference model	0.5	Digital twin
Information Management				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
ISO/IEC JTC 1	ISO/IEC 19510:2013	Information technology – Object Management	0.7	Digital twin

Committee	Document Identifier	Title	Rating	Architecture Component
Information technology		Group Business Process Model and Notation		
ISO/IEC JTC 1/SC 7 Software and systems engineering	ISO/IEC TS 33052:2016	Information technology – Process reference model (PRM) for information security management	0.5	None Currently
Information Security				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
IEC/TC 65 Industrial-process measurement and control	IEC 62443 series [Under development]	Security for industrial automation and control systems	1.0	Secure installation, secure communication, secure authentication/authorisation
ISO/IEC JTC 1/SC 7 Software and Systems Engineering	ISO/IEC TS 33052:2016	Information technology – Process reference model (PRM) for information security management	0.8	None Currently
ISO/IEC JTC 1/SC 27 IT security techniques	ISO/IEC 15408 series	Information technology – Security techniques – Evaluation criteria for IT security	0.8	Security designer
	ISO/IEC 27000:2018	Information technology – Security techniques – Information security management systems – Overview and vocabulary	0.9	None Currently
	ISO/IEC 27001:2013	Information technology – Security techniques – Information security management systems – Requirements	0.9	Security designer
	ISO/IEC 27002:2013	Information technology – Security techniques – Code of practice for information security controls	1.0	None Currently
	ISO/IEC 27005:2018	Information technology - Security techniques – Information security risk management	1.0	Security designer
	ISO/IEC DIS 27009:2019 [Under development]	Information technology – Security techniques – Sector-specific application of ISO/IEC 27001 – Requirements	1.0	None Currently
	ISO/IEC 27017:2015	Security techniques – Code of practice for information security controls based on ISO/IEC 27002 for cloud services	1.0	None Currently
Data Management				

Committee	Document Identifier	Title	Rating	Architecture Component
ISO/IEC JTC 1/SC 32 Data management and interchange	ISO/IEC 6523-1:1998	Information technology – Structure for the identification of organisations and organisation parts – Part 1: Identification of organisation identification schemes	0.6	Security component by IKER, storage
	ISO/IEC 6523-2:1998	Information technology – Structure for the identification of organisations and organisation parts – Part 2: Registration of organisation identification schemes	0.6	Security component by IKER, storage
IoT Architecture				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
IEEE Institute of Electrical and Electronics Engineers	IEEE P2413:2019	Architectural Framework for the Internet of Things (IoT)	1.1	None Currently
Cloud Computing				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
ISO/IEC JTC 1/SC 38 Distributed application platforms and services (DAPS)	ISO/IEC 17788:2014	Information technology – Cloud computing – Overview and vocabulary	1.1	Autonomous computing, distributed computing, storage
Safety of Machinery				
Committee	**Document Identifier**	**Title**	**Rating**	**Architecture Component**
ISO/TC 199 Safety of machinery	ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction	1.0	None Currently
	ISO/TR 22100-4:2018	Safety of machinery – Relationship with ISO 12100 – Part 4: Guidance to machinery manufacturers for consideration of related IT-security (cyber security)	0.6	None Currently
Further				

Committee	Document Identifier	Title	Rating	Architecture Component
CEN/TC 459/SC 3 Structural steels other than reinforcements	EN 10219-1:2006	Cold Formed Welded structural Hollow Sections of non-alloy and fine grain steels – Part 1: Technical delivery conditions	0.8	None Currently
CEN/TC 459/SC 1 0 Steel tubes and iron and steel fittings	EN 10305-3:2016	Steel Tubes for precision applications – Technical delivery conditions – Part 3: Welded cold sized tubes	0.8	None Currently
	EN 10305-5:2016	Steel tubes for precision applications – Technical delivery conditions – Part 5: Welded cold sized square and rectangular tubes	0.8	None Currently
*usage of the standard for the specific component is under discussion				

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