Assembly Lines In CIrculAtion – smart digital tools for the sustainable, human-centric and resilient use of production resources

D7.5

Standardization report (1ˢᵗ)

version 1.0

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Executive Summary

The present deliverable D7.5 provides an overview of the first results of Task 7.5 – Standardization activities, which goes on for the entire duration of the project.

Within this deliverable, the subtask of investigating relevant standards is covered. The knowledge about existing standards is important for the project since it enables the development of solutions which are compliant with the latest standards and further paves the way for upcoming liaison activities with relevant technical committees. This document provides a general summary of the basic knowledge on standardization in order to bring the consortium on a uniform level in this respect. Nevertheless, the focus of this deliverable is on the standardization landscape, which is relevant to the ALICIA project.

In a first step, the methodology of the standards research conducted is described. With essential keywords provided by the consortium and defined areas, a search for standards with a strong link to ALICIA was conducted. International, European, and national (German) standards were included in the standards overview and shared with the project partners in the form of an excel file, a so-called dashboard. Besides providing a summary on relevant aspects regarding project related standards, the dashboard allows the consortium members to search for specific standards by using keywords and to identify standardization gaps. It is therefore used as the basis for the following activities in T7.5. Altogether 372 standards were included in this overview.

The dashboard was also used within this deliverable to provide an overview of the standardization landscape related to ALICIA. The different technical committees on international and European level, which are responsible for the development of the standards, are described. For particularly relevant topic areas related to ALICIA, possible relevant standards and technical committees (TC's) on European and international level are described. The ISO/TC 184 "Automation systems and integration" is of most interest to ALICIA, as 98 standards developed by the ISO/TC 184 are relevant to ALICIA and have been included in the dashboard.

All this information about standardization, standards, and TC's related to ALICIA is supposed to raise awareness within the consortium for the opportunities that standardization can provide for Research and Innovation (R&I) projects. This is the essential basis to develop a standardization strategy for ALICIA and to later implement corresponding standardization activities (see Figure 1). Within ALICIA the contribution to ongoing or the initiation of new standardization activities is sought. A workshop will be held to analyze the need for standardization and thus the existence of possible standardization gaps in connection with ALICIA's work. This will then lead directly to the initiation of standardization activities.

Figure 1: Overview of the subtasks of Task 7.5 – Standardization.

List of acronyms

Acronym	Description
AFNOR	Association française de normalisation (engl: French Standardization Association)
ANSI	American National Standards Institute
BSI	British Standards Institute, Federal Office for Information Security
CD	Committee draft
CEN	Comité Européen de Normalisation (engl: European Committee for Standardisation)
CEN-CLC/JTC	CEN-CENELEC Joint Technical Committee
CENELEC	Comité Européen de Normalisation Électrotechnique (engl: European Committee for Electrotechnical Standardization)
CME	Circular manufacturing ecosystem
CWA	CEN Workshop Agreement
DfSS	Design for Six Sigma
DIN	Deutsches Institut für Normung e.V. (engl: German Institute for Standardization)
DIS	Draft international standard
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (engl: German Commission for Electrotechnical, Electronics, and Information Technologies of DIN and VDE)
EDC	Eclipse data space connector
EFTA	European Free Trade Association
EN standard	European standard
EU	European Union
FDIS	Final draft international standard
FMEA	Failure Mode and Effects Analysis
ICS	International Classification for Standards
IDSA	International Data Space Association
IDTA	Industrial Digital Twin Association e.V.
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEEE SMC	Institute of Electrical and Electronics Engineers Systems, Man, and Cybernetics Society
ISO	International Organization for Standardization
ITU	International Telecommunication Union
IWA	International Workshop Agreement
JTC	Joint Technical Committee
NSB	National Standardization Body
OEM	Original equipment manufacturer
R&I	Research and Innovation
SC	Subcommittee
TC	Technical Committee
TR	Technical Report
TS	Technical Specification
UNE	Asociación Española de Normalización (engl: Spanish Association for Standardization)
VDA	Verband der Automobilindustrie e.V. (engl: Association of the Automotive Industry e.V.)
VDE	Verband der Elektrotechnik Elektronik Informationstechnik (engl: Association for Electrical, Electronic & Information Technologies)
VDI	Verein Deutscher Ingenieure (engl: Association of German Engineers)
VDMA	Verband Deutscher Maschinen- und Anlagenbau e.V. (engl: Association of German Mechanical and Plant Engineering)
WG	Working Group
WP	Work Package

1. Introduction

Standardization[1] is of great importance both at national and European level. Although European standardization activities are in the foreground of the EU-funded research project ALICIA, which is coordinated by Technische Universität München (TUM), international and relevant national standardization is presented, as a transnational harmonization of standardization documents is considered highly relevant and is the basis for the common economic area in the European Union.

ALICIA is about developing a circular manufacturing ecosystem (CME) of industrial production assets such as robotic arms and conveyor belts, which often not reach their maximum service life and become prematurely obsolescent. The machines are prematurely taken out of operation, scrapped, or at best sold for spare parts. The underlaying vision is that production resources will be traded between factories in Europe and reused to their maximum useful life. Thus, it is essential to ensure the applicability, trust, and conformity of ALICIA. Therefore, it is a necessity that ALICIA's solutions are compliant with standards, technical specifications, and procedures. This is a crucial aspect to guarantee that the developed solution is working properly, and the project results are trustworthy. For this reason, ALICIA has integrated standardization as an essential element of the project. Regarding the work structure of ALICIA (Figure 2), standardization is integrated in WP7, in task 7.5.
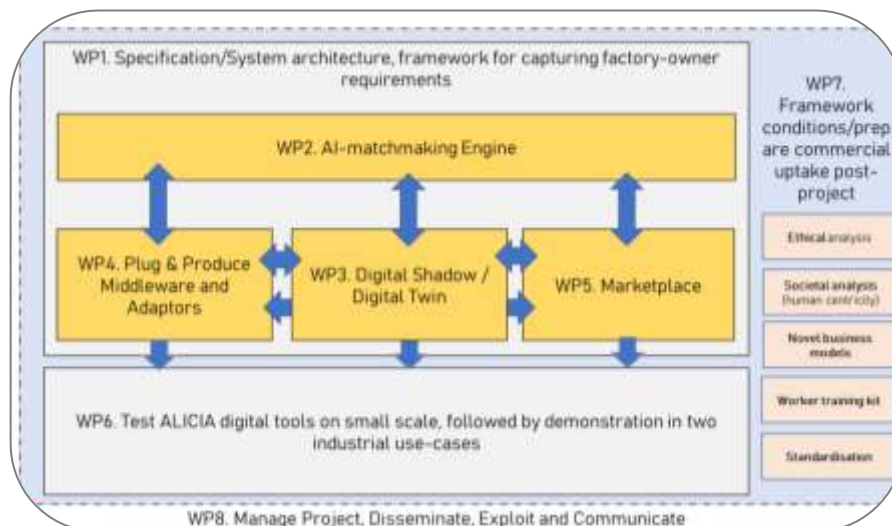
Figure 2: Working structure of the project ALICIA[2]

In WP7 – *Framework conditions/human-centered design for CME/prepare commercial uptake post-project* Task 7.5 – *Standardization* is integrated. One objective of this task is to create a well-grounded overview of the current standards and standardization documents as well as relevant technical committees on national, European, and international level related to ALICIA. This will provide an overview of the state of the art of the standardization landscape that is relevant for the project and thus ensure the compliance of the project's results with what is already on the market. The knowledge about existing standards is of importance for the consortium to align its products, processes, services, and solutions with the current state of the art. The identification of relevant technical committees is the basis for the direct transfer of ALICIA's results into ongoing standardization activities.

The present deliverable 7.5, belonging to Task 7.5, delivers an overview of the standardization landscape and highlights the most relevant standards for ALICIA as well as their impact and implication. Besides the necessity to know about ongoing standardization activities, this

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[1] Standardization covers all types of standardization documents and is used here in a general manner.

[2] adapted from grant agreement project 101091577 – ALICIA

knowledge also provides the opportunity to raise awareness for standardization needs in this area. Therefore, this deliverable supports the activities in WP 8 – *Manage project, disseminate, exploit and communicate,* especially Task 8.4 – *Implement dissemination, exploitation and communication activities according to the DEC Plan and IPR management plan*.

In general, this standardization overview serves as the basis for further standardization activities in ALICIA. Knowing about existing standardization documents makes it possible to build on existing knowledge and avoid unnecessary duplication of work. Additionally, existing gaps in standardization can be better identified and impulses for new standardization activities can be developed.

1.1. Document structure

In contrast to patents, knowledge about standardization is less pronounced, especially in the area of research and innovation. For this reason, the basic principles of standardization are presented in this report (see clause 2) as well as the different facets of standardization at national (subclause 2.2.1), European (subclause 2.2.2), and international level (subclause 2.2.3). Subsequently, the various types of standardization documents (subclause 2.3), the process for creating a CEN Workshop Agreement (CWA) (subclause 2.3.3), and the function of standardization in the context of research projects (subclause 2.4) are presented in more detail. The results of the standardization research for ALICIA are presented by explaining the approach to the standards research (clause 3) and finally by giving an overview of the related standardization landscape (clause 4). Besides a general overview of the standardization landscape of ALICIA (clause 0), the relevant international (subclause 4.2), European (subclause 4.3), and national standardization activities (subclause 4.4) are examined. The standards highlighted as highly relevant for the project are focused on more closely (subclause 4.5). So-called consortial standards also have a strong relation to ALICIA (subclause 4.5.7) and therefore, the relation of selected consortial standards to ALICIA is described.

2. Basics of standardization

The following chapter 2 gives an overview about the basics of standardization including the standard developing organizations, how standardization works, and an explanation of existing standardization documents.

2.1. General

Within ALICIA the standardization part can support the technology development in the context of circular economy also considering social, ethical and environmental aspects. Therefore, it is important to clarify the characteristics of a standard. *In general, a standard is a consensus-based document that is approved by a recognized body or organization, reflecting the state of the art. It should be based on the consolidated results of science, technology, and experience, and aim to promote optimal community benefits.*[3]

Standardization is used to agree on terminologies, methodologies, requirements, characteristics, etc. in specific areas to make a product, process, or service fit for its purpose. Thus, standardization can drive innovative outcomes by agreeing on common product requirements such as interoperability, quality or safety, and provide guidelines for achieving them. Standardization supports the development of a generic language, which is understandable for everyone and thus helps to create a common basis. The result of the standardization process is a document, which provides rules, guidelines or characteristics for activities or their results.

2.2. Standard developing organizations

An essential aspect of standardization is to ensure that standardization documents do not contradict each other, especially since European and international standardization have gained significant importance.This is reflected in DIN's statistics, which show that European and international standards account for 90% of all standardization projects nowadays. The following clauses give a brief description of the framework of formal standardization on international, European, and national level. Figure 3 provides an general overview of the different types and levels of standardization.

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[3] ISO/IEC, „ISO/IEC Guide 2;2004: Standardization and related activities - General vocabulary," 2004
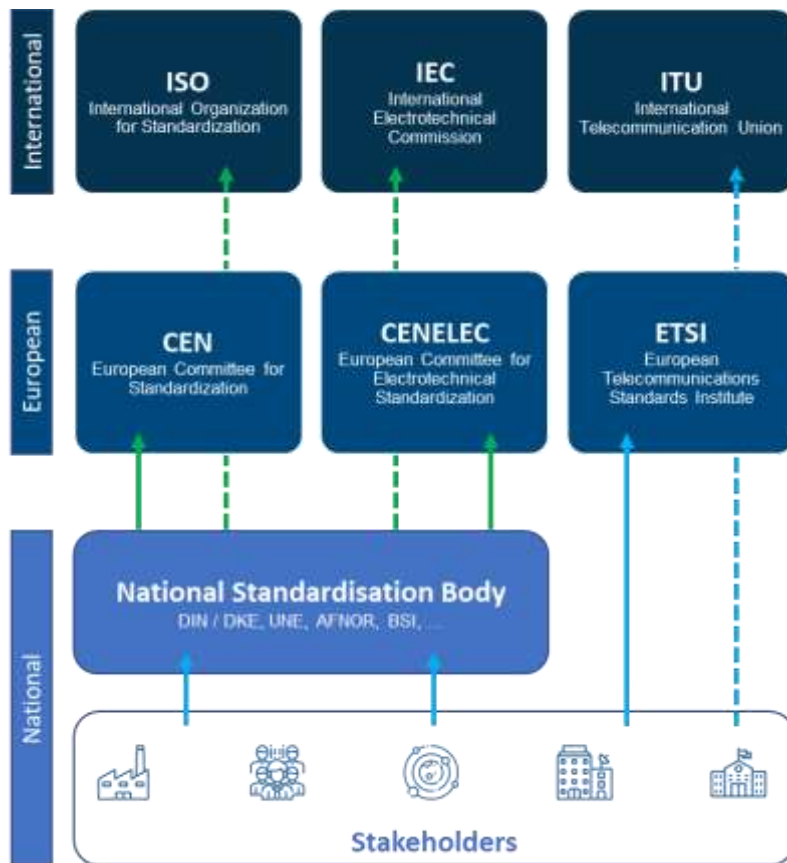
Figure 3: Overview of the organizational structure of the standardization world

2.2.1. National standardization

On national level, there are different structures and standardization bodies in different countries, e.g., German Institute for Standardization (DIN), German Commission for Electrotechnical, Electronic, and Information Technologies (DKE), Spanish standardization body (UNE), the French Standardization Association (AFNOR) and the British Standards Institute (BSI). In general, each country has one or more recognized national standardization bodies (NSB). Within the NSB's experts from different stakeholders, e.g., from organizations belonging to industry, commerce, the public sector, or research, are developing national standards. These NSB's are also responsible for keeping the national standardization repository updated.

To represent national positions at European or international level, so-called mirror-committees are set up and coordinated by the NSB's. In these national committees, the work and existing results of corresponding European and international standardization committees are discussed, a national opinion is developed, and the final drafts of standards are agreed upon. When European or international draft standards are published for comment, the mirror committees also vote on whether the standard should be published or not.

Here it is important to mention, that experts working on European or international level need to be members of the national mirror committee and must be delegated by these committees.

2.2.2. European standardization

The main goal of European standardization is the development of European standards, that are valid and accepted within the EU. These European standards are the basis for the European single market. The European standardization organizations CEN[4] (European Committee for Standardization), CENELEC[4] (European Committee for Electrotechnical Standardization), and ETSI (European Telecommunications Standards Institute) are responsible for the organization of European standardization work. CEN is responsible for all non-electronic activities and CENELEC

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[4] https://www.cencenelec.eu/, last viewed on 28.11.2023

for electrotechnical standardization activities, while ETSI is responsible for the standardization activities in the field of telecommunication at European level.

There is a particularly close cooperation between CEN and CENELEC, which are made up of national standardization organizations from the EU and EFTA (European Free Trade Association) member states, as well as states seeking membership. In contrast, the members of ETSI are directly European companies, institutes, and organizations.

The so-called delegation principle applies to CEN and CENELEC. This means, that the mirror committees of the national standardization bodies of their member states, send national experts to the technical committees and workings groups at CEN or CENELEC to develop European standards. The European standard (EN) will only be published, when a sufficiently large majority of the national standardization organizations has approved the final draft.

European standards (EN) must automatically be adopted by member states of the EU and opposing national standards must be withdrawn. As a result of this mandatory adoption, the EN standards in Germany then become DIN EN standards (e.g., DIN EN 16575). There are situations in which it is possible to complement EN standards with additional national standards, for instance to set more detailed requirements to meet specific needs of the member state.

European specifications are referred to as CWA as well as CEN TS or CENELEC TS, depending on the type of development and their adoption by the member states is voluntary (e.g., DIN CEN/TS 17045), unlike the adoption of European Standards.

2.2.3. International standardization

The international standardization organization ISO [5] (International Organization for Standardization), IEC [6] (International Electrotechnical Commission), and ITU [7] (International Telecommunication Union) are responsible for the organization of international standardization work. ISO is responsible for all non-electronic and IEC for electrotechnical standardization activities, while the ITU is in charge of standardization activities in the field of telecommunications. ISO and IEC are made up of the national standardization organizations, with e.g., DIN and DKE representing German interests on an international level. The ITU, on the other hand, is a special unit of the United Nations, whose 191 member states develop recommendations together with companies from the private sector and other regional and national organizations. Only when they are adopted by normative organizations such as ISO, ANSI (USA) or ETSI as well as by national regulatory authorities, such as the Federal Network Agency in Germany, they acquire the character of standards.

The so-called delegation principle also applies to ISO and IEC, meaning that the national standardization organizations send their experts to the working groups and technical committees of the international standardization bodies. An international standard (ISO) is only accepted, when a sufficiently large majority of the national standardization organizations has voted for its draft. International specifications are called International Workshop Agreement (IWA) as well as ISO TS or IEC TS, depending on the type of development.

In contrast to European standardization, there is no obligation to adopt international standards in national standards. However, since internationally applicable standards are relevant for international trade or for global stakeholders, conflicting national or European standards should be avoided. There is the possibility of transferring international standards in European and national standards. The resulting documents have the characteristics and names listed in Table 1, depending on the background. There are also parallel processes for developing standards at international and European level. It is possible to directly develop EN ISO or EN IEC standards without first developing the standard on international level and then adopting it at European level.

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[5] www.iso.org , last viewed on 28.11.2023

[6] https://www.iec.ch/, last viewed on 28.11.2023

[7] https://www.itu.int, last viewed on 28.11.2023

Table 1: Names of international standards depending on their adoption level

Name	Description
ISO XXXXX	International standard adopted on neither national nor European level
DIN ISO XXXXX	International standard adopted only on national (Germany) level
DIN EN ISO XXXXX	International standard adopted on European and national level

2.3. Standardization documents

2.3.1. General

There are several types of standardization documents that differ in their development process, the degree of consensus to be reached, and the openness to participation (Figure 4). Standardization documents describe products, systems or services by defining their characteristics and requirements and in many cases are publicly available. The fastest way to develop a standard is to develop consortial standards. However, the development process has the lowest degree of openness to participation. For the purpose of achieving a higher degree of consensus through the participation of all interested parties and developing a standardization document relatively quickly, specifications are suiteable. The highest level of consensus, but also the longest development time, is achieved by a standard. The different types of standardization documents are described in more detailed in the following subclauses.
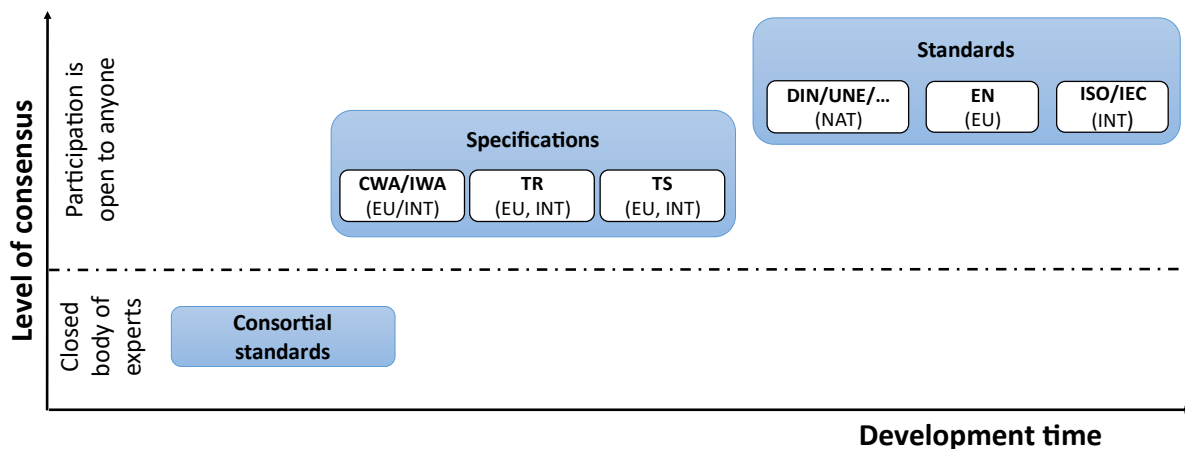
Figure 4: Types of standardization documents

2.3.2. Standard

According to Figure 4, **standards** in the narrower sense are developed within the formal standardization system where all interested parties have to be included in the development process of the document and consensus, meaning the general agreement of all participants and the lack of sustained objection to central content, must be reached. Therefore, a public commenting phase is mandatory in the development of standards. The main objective of the consensus is to take into account the views of all interested parties concerned and to dispel any counter-arguments. The development of a European standard is shown in Figure 5.

01

Anyone can submit a proposal for standards work.

The responsible committee reviews the **need** for a standard in this sector.

02

Stakeholders develop content of standards in a consensus-based process.

A total of **more than 200 000 experts** from industry, research, politics and consumer protection bring their expertise to standards work.

03

The draft standard is made available for public comment.

All those involved in the standards project **revise** the standard based on the **comments** received.

04

CEN publishes the final EN Standard…

… and **reviews** it no later than every five years.

Figure 5: Development of a standard

First of all, anyone who has identified a need for a standard can submit a proposal for a new standard. In most cases this has to be done via the national mirror committee. The associated standards committee evaluates the need and whether standardization activities are already taking place or if standards that cover the described need exist. If the need is confirmed, a standard is then developed in a standardization committee. Attention is paid to a balanced composition of these committees with all interested parties concerned (science, consumers, industry, ...) in order to guarantee the neutrality of the documents. A final draft, approved by the standards committee, is then released for public comment. All comments have to be discussed before the final standard is approved by the standardization committee. Due to the high level of transparency and the involvement of the public, the development time increases from national to European and international level. National standards usually require 18 months to develop, while the development of European and international standards normally takes more than two years due to the involvement of the national standardization bodies.[8] Due to the high degree of consensus, standards have a high level of acceptance in society.

2.3.3. Specification

To better understand the difference between the various standardization documents, the terms specification and standard are used. However, in many cases both documents will be called standards. In contrast to a standard developed in consensus, the standardization activities in research projects focus mainly on the development of **specifications**. Compared to a standard, consensus is not mandatory in specifications and the involvement of all interested parties is not obligatory. The development of a specification, e. g. CWA on European level, is shown in Figure 6.

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[8] https://www.iso.org/developing-standards.html, last viewed on 28.11.2023

01

Anyone can initiate a specification

A specification is the **fastest way** to take an innovative idea and establish it on the market.

02

During the workshop phase, the parties develop the content of the specification

Specifications do not require full consensus and the involvement of all stakeholders. The workshop participants decide whether or not to make the pre-standard draft available for public comment.

03

A Standardization organization publishes the final specification…

… so that innovative solutions can quickly be established on the market. Any specification can be used as a **basis for developing a full Standard.**

Figure 6: Development of a specification

Anyone can submit an application to develop a specification. The scope of the specification will be compared with the existing standardization repository. If no conflicting standards exist, the standardization organization publishes the business plan for public comment and a call for cooperation from interested organizations. In contrast to standards, specifications are created in workshops (temporary committee). A standardization organization acts as a secretary to ensure the procedural requirements and to support the members of the workshops in developing the specification. The workshop also decides whether a draft should be published for comment and once a specification has been successfully adopted by the workshop, the specification will be published.

There are different types of specifications. A Workshop Agreement on European (CEN/CENELEC Workshop Agreement, CWA) or international (International Workshop Agreement, IWA) level is developed in a temporary workshop, which is designed to meet an immediate need and forms the basis for future standardization activities lead by a national standardization body. Even if there are not as strict rules for developing a specification as there are for standards, it is important to ensure the coherence of the standardization regulations to protect the credibility of international, European, and national standardization. The workshop is open to direct participation by anyone who is interested in the development of the agreement but consensus is not required. The development of a Workshop Agreement is fast and flexible, on average between 10 and 12 months and therefore also attractive for research projects. Temporary workshops also develop national specifications, such as DIN SPECs (e.g., DIN SPEC 91392) in Germany.

Specifications can also be developed within standards committees if, for example , no final consensus can be reached. These documents are then referred to as CEN or ISO TS (Technical Specifications). A TS on European level may not conflict with a European standard but conflicting national standards may continue to exist. Technical Reports (TR) are consortial documents that are developed and approved by a technical committee. A TR provides information on technical content and standardization work.

2.3.4. Consortial standard

Regarding the development time, the fastest ones are **consortial standards** (see Figure 4), also called industry, informal or de-facto standards. Among other things, they are characterised by the fact that not all interested parties need to be included in the development process. These closed group of experts can be, e. g., industry-specific consortia that have been formed from different companies. Although these documents have some characteristics of a standardization document, such as defined procedures or documentation rules, consortial standards are often not freely accessible and are developed in private.

2.4. Standardization in research projects

It is crucial for an R&I project to know the state of the art in the areas relevant for or connected to the project. Since standards reflect this state of the art in a specific area it is essential for R&I projects to have an overview of the standardization landscape related to the project. This knowledge enables the project to tailor its results or findings to current market requirements and helps ensure that they are interoperable with existing solutions. R&I projects need to consider the developments within other relevant activities. Irrespective of the technical merits of the R&I project developments, these efforts will be inconsequential if developed in isolation and the market decides to follow another path.

Furthermore, the knowledge about related standards also enables the R&I project to overcome additional challenges and go beyond the current state of the art. On the one hand, an overview of the related standardization landscape offers an R&I project the advantages described above. On the other hand, awareness is raised on where standardization is still needed. This opportunity can be used by the R&I project to implement project results in already ongoing standardization activities or by developing new standards/specifications from project results.

For ALICIA in particular, aspects of standardization play an important role. The European research framework program Horizon Europe addresses the topic of standardization in a series of calls for proposals.

3. Methodology: How the ALICIA standardization landscape was developed

This clause describes how the standardization landscape relevant for ALICIA was developed. A standardization landscape for a specific topic provides an overview of the existing standards relevant and related to the defined topic(s). Such an overview of the standardization landscape should raise awareness among the project partners on what already exists on the market and prevents them from re-inventing the wheel. Further, the standardization landscape provides the basis for further standardization activities of the project. The approach to developing a standardization landscape is shown in Figure 7.
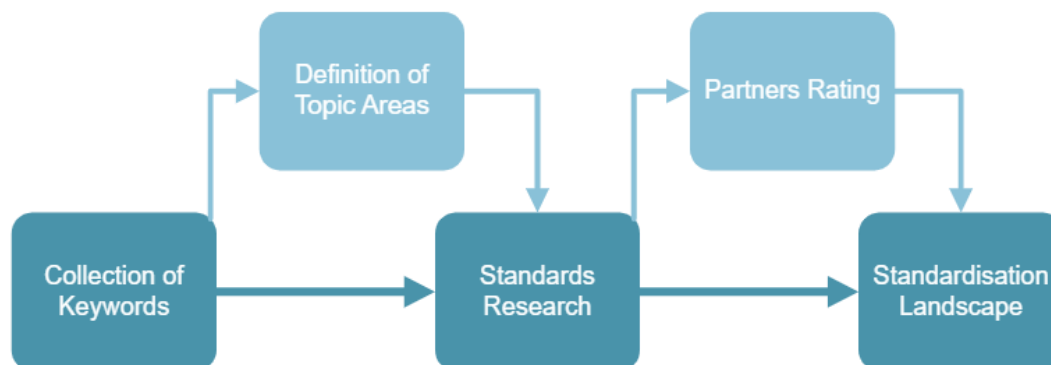
Figure 7: Steps for the development of a standardization landscape within ALICIA

As a first step Keywords with relation to the different tasks within ALICIA are collected from the partners. They were grouped into broader topic areas and used in a second step for the standards research. The standards which came up during this research were rated by the project partners with regard to their relevance for their work within ALICIA. Those relevant standards constitute the standardization landscape for ALICIA. Those steps are described in more detail in the following subclauses.

3.1. Training "Basics on Standardization"

In order to gain a sufficient basis for the upcoming standardization tasks within the consortium, a training "basics in standardization" was performed at the beginning of the project. Within this training the following points were addressed:
- *Why are standards important for Research and Innovation projects?*
- *What are the results of standardization?*
- *How are standards and specifications developed?*
- *How can ALICIA participate in standardization and how can the results of the project/project results be disseminated?*

13 people from six different organizations participated in the training "basics on standardization". The presentation was made available to the entire consortium on the online project platform and can be found in annex 1.

3.2. Survey on partners' expertise regarding standardization and keyword collection

The basis for providing a standardization landscape for the consortium is the standards research where all standards relevant to the project are collected. The first step to performing this standards research was to get an overview of the partners' knowledge, activities, and expectations regarding standardization within ALICIA. In this context, a survey was conducted, where the partners were asked to answer questions about their expertise on standardization. 13 people from 7 different partner organizations participated in the survey. The questions and the corresponding answers are listed in annex 2.

A small part of the project consortium is already familiar with standardization. Three people from three different organizations have been or are currently active in standardization, and one person has already participated in the development of a pre-standardization document such as a CWA. Within the ALICIA project, nine people are applying or planning to apply standards as part of their activities within ALICIA, including digitalization, industrial interoperability, and manufacturing systems, etc. In particular, quality management standards, such as ISO 14040 or ISO 9001, as well as standards related to the design of manufacturing systems and safety of machinery are of interest for ALICIA and are already known or used within ALICIA.

The survey showed that some partners already are aware of areas with standardization gaps. This involves circular manufacturing, the connectivity of machines and the exchange of data between machines, the architecture of manufacturing systems and digitalization of production systems, as well as standards for the re-use of equipment, among other things to increase trust and acceptance for the sector of buying and selling used machinery.

In order to provide the consortium with an overview of already existing standards and standards under development in the areas relevant for ALICIA, a standards research was conducted. For this reason, keywords were collected from the project partners as part of the survey described above. The partners were asked for which specific areas/topics they would like to get an overview of the existing standards, which led to the identification of five relevant topics: *Circular Economy, Digitalization/IT, Industry, Automation, and Other*. The keywords were matched to the identified topics and are listed in

Table 2. The keywords were used to identify standardization documents and other TC's related to ALICIA. They were also used to search for existing standards (standards research), using the standards data base Nautos[9]. To identify further standards of interest, the standards research was extended to modifications and alternatives to the keywords provided by the partners.

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[9] https://nautos.de/, last viewed on 27.11.2023

Table 2: Supplied keywords by ALICIA partners and added keywords by DIN (*).

Topic: Circular Economy	
Circularity	Environmental Product Declaration
Circular Economy	Environmental management
Circular manufacturing	LCA / LCA assessments
Circular manufacturing ecosystems	Social LCA
Sustainability for manufacturing/sustainable manufacturing	Second use*
Sustainable business models	Used goods / used machines*
Product Environmental Footprint	
Topic: Digitalization/IT	
Digital tools for manufacturing	Digitalization of production systems
Digital tools in automation	Industrial digital twin
Digital tools	digital product passport
Digitalisation / digitalization	Digital platform activities
Industrial IoT	Digital platform*
Architecture	IT security
Machine connectivity	
Topic: Industry	
Machine communication	GS1 standards: (RAMI 4.0)
Industry 4.0	Standardized ways to specify worker skills
industrial data spaces	Operator safety standards
Industrial Interoperability	Mechanical Design
Manufacturing systems architecture(s)	Equipment health assessment*
Middleware(s)	Controls Design
Assembly process(es)	Retrofit/retrofitting*
Assembly resources	
Topic: Automation	
Automation	
Topic: Quality management	
Quality management	
Topic: Others	
Ethical (assessment)	Artificial intelligence

3.3. Standards research

For the standards research, mainly the search engine Nautos was used to find formal standards. The database includes national standards as well as standards from the European organizations CEN, CENELEC, ETSI, and international organizations such as ISO, IEC, and ITU. Technical documents and reports on these levels have been considered for the analysis. In case of national standards, it should be noted that due to language barriers mostly those providing at least one English title have been considered. Since one third of the project partners comes from German organizations and Germany is a pioneer in the automotive industry, the standards research focused on German standards in the context of national standards. If required, other national standards can also be searched for. All the hits from the Nautos search, using the different keywords, resulted in a list of 2304 standards.

Besides the keywords used for the Nautos research, the project partners also mentioned organizations that are not standardization bodies or developing consortial standards. These are listed in the subclause 4.5.7.

An analysis and assessment of the standards relevant and important to ALICIA was conducted by the consortium. The identification of these standards was done by filtering the list of standards by keywords relevant for the specific areas and an individual evaluation based on the title as well as the abstract of the standards. Based on their expertise, at least two partners were chosen to evaluate the preliminary list of standards relevant to their topic of expertise. The standards were rated according to their relevance and partners could choose between the following criteria: relevant, not relevant, already used within ALICIA. This way 373 formal standards were highlighted as relevant for ALICIA. The following table shows the number of relevant standards per topic.

Table 3: List of number of relevant standards per topic before and after partners rating

Topic	Number of standards after standards research	Number of standards after partner's rating
Circular Economy	340	57
Digitalization	559	56
Industry	479	111
Automation	860	89
Quality Management	56	24
Others	10	4

These standards represent the first overview of the standardization landscape for ALICIA and were therefore shared with the partners of the consortium in the form of a dashboard (Figure 8). All standards are listed in a complete list in annex 3.

An initial version of the dashboard with all relevant standards was provided in September 2023. The dashboard is an Excel template, which was developed specifically for the research of standards and provides an overview of the main information regarding the relevant standards. It can be used to search for specific standards by keywords or to get an overview of the standards within a specific ICS (International Classification for Standards) field or developed by a specific technical committee. The ICS is intended to serve as a structure for catalogues of international, regional, and national standards and other normative documents, and as a basis for standing-order systems for international, regional, and national standards.[10] This dashboard was shared within the whole ALICIA consortium. An explanation of how standards of interest can be identified using this dashboard was given in a virtual standardization session at the end of September 2023. Nine partners from seven different organizations participated in this meeting. Furthermore, for each topic identified using the keywords, a list of standards was provided. These lists were sorted from highest to lowest, counting the number of keywords found in the standards..

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[10] International Classification for Standards, 2015; Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/international_classification_for_standards.pdf, last viewed on 24.11.2023

Figure 8: Dashboard with the relevant standards for ALICIA

Since the development of standards does not stand still, the dashboard will be updated annually.

4. Overview of the ALICIA standardization landscape

This section gives an overview of the standardization landscape related to ALICIA. Besides providing a general overview of standards which could be relevant for ALICIA, relevant standardization committees that are active in the fields interesting for ALICIA are also given. As a basis for this analysis the dashboard described in subclause 3.3 was used.

4.1. General

The dashboard is used to provide some general information on standards that might be relevant to ALICIA. TheFigure 9 origin of the documents included in the ALICIA dashboard is visualized in Figure 8. The majority (66%) of standards were developed on international level, whereas around 14% originated on European level, and 20% on national level. ALICIA is a European research project and therefore individual national standards are of secondary importance for the first overview of the standardization landscape. Figure 10 breaks down the types of the standardization documents listed. 77% of the documents included in the dashboard are standards in the narrower sense (see subclause 2.3.2) like ISO- / EN- or national standards, whereas the rest are specifications. Nearly 47% of the documents were published within the last 5 years.

Figure 9: Level of standards.
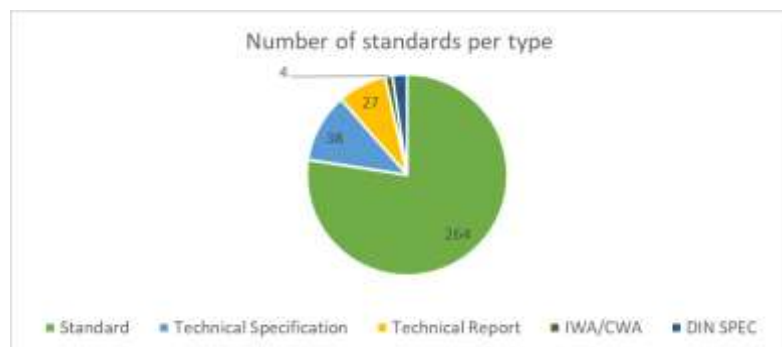
Figure 10: Type of standardization documents.

The standards related to ALICIA cover a wide range of different areas. Based on the International Classification for Standards (ICS) fields, an overview of the different areas can be given (Table 4). For this overview only ICS fields which are assigned to at least 50 standards are listed in Table 4.

Table 4: Overview of the number of standards in the different ICS fields.

	ICS field	Number of standards
25 - Manufacturing Engineering	*25.040 – Industrial automation systems*	162
	25.120 – Chipless working equipment	6
	25.060 – Machine tool systems	3
	25.080 – Machine tools	3
	25.030 – Additive manufacturing	2
	25.020 – Manufacturing forming processes	2
	25.140 – Hand-held tools	1
	25.160 – Welding, brazing and soldering	1
	25.180 – Industrial furnaces	1
35 – Information technology	*35.240 – Applications of information technology*	109
	35.020 – Information technology (IT) in general	13
	35.030 – IT Security	9
	35.200 – Interface and interconnection equipment	8
	35.080 – Software	7
	35.100 – Open systems interconnection (OSI)	6
	35.040 – Information coding	2
	35.160 – Microprocessor systems	2
	35.060 – Languages used in information technology	2
	35.210 – Cloud computing	1
	35.180 – IT-terminal and other peripheral equipment	1
13 – Environment. Health protection. Safety	*13.020 – Environmental protection*	66
	13.110 – Safety of machinery	11
	13.180 – Ergonomics	6
	13.030 – Wastes	4
	13.220 – Protection against fire	1

The standards are part of 19 different ICS fields, with ICS field 25, ICS field 35, ICS field 13, and ICS field 03 being the most present ones. It is important to keep in mind that one standard can be part of several different ICS fields. 53% of the standards included in the ALICIA dashboard are classified within ICS field 25 – *Manufacturing Engineering*. Nearly the same amount (47%) of standards is included in ICS field 35 – *Information technology*. The third largest amount of standards are part of ICS field 13 – *Environment. Health protection. Safety* (26%).

4.2. Standardization activities on international level

Of the standards that could be relevant for ALICIA, 224 documents at international level were included in the ALICIA dashboard. The main technical committees, which are responsible for these standards, are listed in

Table 5 and are described in the following. Only TC's that published more than five standards of the ones included in the dashboard are listed and described below. In addition, relevant standards under development are listed below.

Table 5: Relevant standard setting organizations and TC's on international level.

TC	Title

ISO/TC 184	Automation systems and integration
ISO/TC 207	Environmental management
IEC/TC 65	Industrial-process measurement, control and automation
IEC/TC/SC 65A	System aspects
IEC/TC/SC 65E	Devices and integration in enterprise systems
ISO/IEC JTC 1	Information technology
ITU	International Telecommunication Union (ITU)

4.2.1. ISO/TC 184

The scope of this TC is standardization in the field of automation systems and their integration for design sources, manufacturing, production and delivery, support, maintenance and disposal of products and their associated services. Areas include information systems, automation and control systems, and integration technologies. The ISO/TC 184 will actively collaborate with the relevant technical committees responsible for areas such as machines, manufacturing resources and facilities, robotics, electrical and electronic equipment, PLC for general application, quality management, industrial safety, information technologies, multi-media capabilities, and multi-modal communication networks.[11] The secretariat of this TC is held by AFNOR, the French standardization body.

The TC 184 is divided into three subcommittees (SC) and seven working groups (WG). The most relevant SC for ALICIA are listed in the following:

- *ISO/TC 184/SC 1: Industrial cyber and physical device control*
- *ISO/TC 184/SC 4: Industrial Data*
- *ISO/TC 184/SC 5: Interoperability, integration, and architectures for enterprise systems and automation applications*
- *ISO/TC 184/AG 2: Digital Twin*
- *ISO/TC 184/AHG 2: Environmental criteria*
- *ISO/TC 184/JWG 21: Smart Manufacturing Reference Model(s) linked to ISO/TC 184*
- *ISO/TC 184/WG 6: Asset intensive industry interoperability*

This TC has published 891 ISO standards so far and is currently working on 99 ISO standards. In the following, the most relevant standards on which the TC and relevant SC are currently working on are listed with their respective stage code below. The stage codes describe the working status of a standardization document. The meaning of each stage code can be found in annex 4. Table 6 shows standards under development from the ISO/TC 184.

Table 6: Standards under development from the ISO/TC 184.

Document number	Title	Stage code
IEC/CD TR 63319	A meta-modelling analysis approach to smart manufacturing reference models	30.99
IEC/FDIS 63339	Unified reference model for smart manufacturing	50.20

In the SC 1 one document is currently under development (see Table 7).

Table 7: Standards under development from the ISO/TC 184/SC1 - Industrial cyber and physical device control.

Document number	Title	Stage code

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[11] https://www.iso.org/committee/54110.html, last viewed on 09.10.2023

Document number	Title	Stage code
ISO/AWI 23704-4	Reference Model for Cyber-Physically Controlled Smart Machine Tool Systems (CPSMT) — Part 4: Part 4: Requirements and guidelines for implementing reference architecture of CPSMT for subtractive manufacturing	20.20

Table 8 shows the documents under development from the ISO/TC 184/SC 4.

Table 8: Standards under development from the ISO/TC 184/SC 4 - Industrial Data.

Document number	Title	Stage code
ISO/AWI 8000-1	Data quality – Part 1: Overview	20.00
ISO/AWI 8000-114	Data quality – Part 114: Master data: Application of ISO/IEC 21778 and ISO 8000-115 to portable data	40.60
ISO/AWI 8000-118	Data quality — Part 118: Application of ISO 8000-115 to natural location identifiers	30.99
ISO/AWI 8000-200	Data quality — Part 200: Transaction data: Quality of transaction data	20.00
ISO/AWI 8000-210	Data quality — Part 210: Part 210: Sensor data: Data quality characteristics	30.60
ISO/AWI 8000-220	Data quality — Part 220: Sensor data: Quality measurement	20.00
ISO/DPAS 8329	xMCF — Description and data standard for connection and joining data in structural systems	50.00
ISO/PRF 10303-1	Industrial automation systems and integration — Product data representation and exchange — Part 1: Overview and fundamental principles	50.00
ISO/FDIS 10303-2	Industrial automation systems and integration — Product data representation and exchange — Part 2: Vocabulary	50.00
ISO/CD TS 10303-15	Industrial automation systems and integration — Product data representation and exchange — Part 15: Description methods: SysML XMI to XSD transformation	30.99
ISO/DIS 10303-239	Industrial automation systems and integration — Product data representation and exchange — Part 239: Application protocol: Product life cycle support (PLCS)	40.20
ISO/CD TS 10303-439	Industrial automation systems and integration — Product data representation and exchange — Part 439: Application module: AP239 product life cycle support	30.99
ISO/CD TS 10303-1251	Industrial automation systems and integration — Product data representation and exchange — Part 1251: Application module: Interface	30.99
ISO/CD TS 10303-1253	Industrial automation systems and integration — Product data representation and exchange — Part 1253: Application module: Condition	30.99
ISO/CD TS 10303-1254	Industrial automation systems and integration — Product data representation and exchange — Part 1254: Application module: Condition evaluation	30.99
ISO/CD TS 10303-1348	Industrial automation systems and integration — Product data representation and exchange — Part 1348: Application module: Requirement management	30.99
ISO/CD TR 17999	Reference model for industrial data	30.92
ISO/AWI 23247-5	Automation systems and integration — Digital twin framework for manufacturing — Part 5: Part 5: Digital thread for digital twin	20.00
ISO/AWI 23247-6	Automation systems and integration — Digital twin framework for manufacturing — Part 6: Part 6: Digital twin composition	20.00

Table 9 shows the standards under development from ISO/TC 184/SC 5.

Table 9: Standards under development from the ISO/TC 184/SC 5: Interoperability, integration, and architectures for enterprise systems and automation applications.

Document number	Title	Stage code
ISO/PRF 16400-2	Automation systems and integration - Equipment behavior catalogues for virtual production system - Part 2: Formal description of catalogue template	50.20
ISO/DIS 16400-3	Automation systems and integration - Equipment behavior catalogues for virtual production system - Part 3: Guideline for construction of equipment instance model	40.99
ISO/PRF 19450	Automation systems and integration - Object-Process Methodology	50.20
ISO/DIS 20140-5	Automation systems and integration — Evaluating energy efficiency and other factors of manufacturing systems that influence the environment — Part 5: Environmental performance evaluation data	40.60
ISO/AWI 20850	Supply chain interoperability and integration — Part 210: Strategic sourcing concepts, principles, and data requirements	20.00
ISO/AWI 21175-1	Automation systems and integration --Collaboration Environment Requirements of Simulation on Different Manufacturing Platforms — Part 1: Part 1: Reference Model and Process	20.00
ISO/AWI 22400-1	Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management — Part 1: Overview, concepts and terminology	10.99
ISO/AWI 22400-2	Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management — Part 2: Definitions and descriptions	30.00

4.2.2. ISO/TC 207

The scope of the ISO/TC 207 is to address environmental and climate impacts, including related social and economic aspects, in support of sustainable development. TC 207 is focused on environmental management systems, auditing, verification/validation and related investigations, environmental labelling, environmental performance evaluation, life cycle assessment, climate change and its mitigation and adaptation, ecodesign, material efficiency, environmental economics and environmental and climate finance. Where appropriate, the ISO/TC 207 works in cooperation with existing committees on subjects that may support environmental management.[12] The secretariat is held by the Standards Council of Canada. The ISO/TC 207 is divided into six sub committees and seven working groups. The sub committees most relevant for ALICIA are listed below:

- *ISO/TC 207/SC 1: Environmental management systems*
- *ISO/TC 207/SC 5: Life cycle assessment*
- *ISO/TC 207/SC 7: Greenhouse gas and climate change management and related activities*

The ISO/TC 207 has published 67 ISO standards so far and currently works on 19 ISO standards. The following standards are currently under development and could be of interest for the project. Table 10 shows the standards under development from ISO/TC 207/SC 1.

Table 10: Standards under development from the ISO/TC 207/SC 1 – Environmental management systems

Document number	Title	Stage code

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[12] https://www.iso.org/committee/54808.html, last viewed on 09.10.2023

	Environmental management systems — Guidelines for using	
ISO 14002-4	ISO 14001 to address environmental aspects and conditions within an environmental topic area — Part 4: Part 4: Resources and waste	20.20

The following standards in
Table 11 are currently under development from ISO/TC 207/SC5.

Table 11: Standards under development from the ISO/TC 207/SC 5 – Life cycle assessment

Document number	Title	Stage code
ISO/DIS 14071	Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006	40.00
ISO/DIS 14072	Environmental management — Life cycle assessment — Requirements and guidelines for organizational life cycle assessment	40.00
ISO/DIS 14075	Environmental management — Principles and framework for social life cycle assessment	40.00
ISO/WD TS 14076	Eco-Technoeconomic Analyses: Principles, requirements and guidelines	20.60

Table 12 shows the standards under development from ISO/TC 207/SC 7.

Table 12: Standards under development from the ISO/TC 207/SC 7 - Greenhouse gas and climate change management and related activities

Document number	Title	Stage code
ISO 14002-4	Environmental management systems — Guidelines for using ISO 14001 to address environmental aspects and conditions within an environmental topic area — Part 4: Part 4: Resources and waste	20.20
ISO/DIS 59014	Environmental management and circular economy — Sustainability and traceability of secondary materials recovery — Principles and requirements	40.00

4.2.3. IEC/TC 65

IEC/TC 65 deals with the preparation of international standards for systems and elements used for industrial process measurement, control and automation in order to coordinate standardization activities which affect integration of components and functions into such systems including safety and security aspects.[13]I The secretariat is held by AFNOR. The technical committee is divided into four subcommittees and eleven working groups as well as four joint working groups with other technical committees. The following committees could be relevant for ALICIA:
- *IEC/SC 65A: System aspects*
- *IEC/SC 65E: Devices and integration in enterprise systems*
- *IEC/TC 65/WG 16: Digital factory*
- *IEC/TC 65/WG 19: Life-cycle management for systems and products used in industrial-process measurement, control and automation*
- *IEC/TC 65/WG 23: Smart Manufacturing Framework and Concepts for industrial-process measurement, control and automation*
- *IEC/TC 65/WG 24: Asset Administration Shell for Industrial Applications*

The IEC/TC 65 has published 49 IEC standards so far and currently works on 20 IEC standards.

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[13] https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1250,25, last viewed on 09.10.2023

The Subcommittee 65A is part of IEC/TC 65 and deals with System aspects, especially generic aspects of systems used in industrial process measurement, control and manufacturing automation. The committee is led by the United Kingdom and is divided into seven working groups.[14]

The following working groups could be of interest:
- *IEC/TC 65/SC 65A/WG 16: Evaluation of systems properties for the purpose of system assessment*
- *IEC/TC 65/SC 65A/WG 19: Human Machine Interfaces for Process Automation Systems*
- *IEC/TC 65/SC 65A/WG 21: Artificial intelligence – Functional Safety and AI systems – Requirements*

The following standards in Table 13 are currently under development and could be of interest for the project:

Table 13: Standards under development from the IEC/TC 65/SC 65A – systems aspects

Document number	Title	Subcommittee
IEC 63303 ED1	Human-Machine Interfaced for Process Automation Systems	SC 65A/WG 19
ISO/IEC TS 63521 ED1	Artificial intelligence – Functional Safety and AI systems - Requirements	SC 65A/WG 21

Another Subcommittee of IEC/TC 65 of interest is the SC 65E. It deals with devices and integration in enterprise systems and is led by the United Stated of America.[15] There are ten working groups within this subcommittees. The following are the interesting ones:
- *IEC/TC 65/SC 65E/WG 4: Field device tool interface specification*
- *IEC/TC 65/SC 65A/WG 7: FB for process control, EDDL and FDI*
- *IEC/TC 65/SC 65A/WG 8: OPC*
- *IEC/TC 65/SC 65A/WG 9: AutomationML – Engineering Data Exchange Format*
- *IEC/TC 65/SC 65A/WG 12: Predictive Maintenance*

The following standards in Table 14 are currently under development and could be of interest for the project:

Table 14: Standards under development from the IEC/TC 65/SC 65E – devices and integration in enterprise systems

Document number	Title	Subcommittee
IEC 62453 series (part 2, 42, 43, 51-20, 52-31, 52-90, 53-31, 53-90, 71, 302)	Field device tool (FDT) interface specification	SC 65E/WG 4
IEC 62541 series (part 1-24, 100)	OPC Unified Architecture	SC 65E/WG 8
IEC 62714-6 ED1	Engineering data exchange format for use in industrial automation systems engineering - Automation Markup Language - Part 6: AutomationML Components	SC 65E/WG 9
IEC 63270 ED1	Industrial automation equipment and systems - Predictive maintenance	SC 65E/WG 12

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[14] https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1369,25, last viewed on 09.10.2023

[15] https://www.iec.ch/dyn/www/f?p=103:7:408336511942763::::FSP_ORG_ID,FSP_LANG_ID:1452,25, last viewed on 09.10.2023

4.2.4. ISO/IEC JTC 1

Another relevant technical committee is the ISO/IEC Joint Technical Committee 1 (JTC 1), which deals with the standardization in the field of information technology. The ISO/IEC JTC 1 is divided into 23 subcommittees and 16 working groups.[16]

The most interesting subcommittee within is the ISO/IEC JTC 1 is the SC 41 with the title "Internet of things and digital twin". This committee deals with Standardization in the area of Internet of Things and Digital Twin, including their related technologies.[17] This group provides guidance to JTC 1, IEC, ISO and other entities developing Internet of Things and Digital Twin related applications. The secretariat is held by the Korean Agency for Technology and Standards.[18] The technical committee is divided into five working groups. The most interesting ones for ALICIA are the following:

- *ISO/IEC JTC 1/SC 41/WG 3: IoT Architecture*
- *ISO/IEC JTC 1/SC 41/WG 4: IoT Interoperability*
- *ISO/IEC JTC/SC 41/WG 5: IoT Applications*
- *ISO/IEC JTC/SC 41/WG 6: Digital twin*

This ISO/IEC JTC1/SC 41 has published 43 ISO standards so far and currently works on 3 ISO standards. The standards shown in Table 15 are currently under development:

Table 15: Standards under development from ISO/IEC JTC 1/SC 41

Document number	Title	Stage code
ISO/IEC AWI 30149	Internet of things (IoT) – Trustworthiness framework	10.99
ISO/IEC AWI 30172	Digital Twin – Use cases	10.99
IS/IEC AWI 30371	Digital Twin – Concepts and terminology	20.00

4.2.5. ITU

The ITU is the International Telecommunication Unit, which deals with technical aspects in terms of telecommunication. There are eleven study groups, which carry out the standardization work.[19] Eight standards were identified as relevant for ALICIA. The following study groups could be of interest for ALICIA:

- *SG5 - EMF, environment, climate action, sustainable digitalization, and circular economy*
ITU-T Study Group 5 (SG5) is the leading study group on electromagnetic fields (EMF), environment, climate action, sustainable digitalization, and the circular economy. The international standards (ITU-T Recommendations) and related texts developed by SG5 provide guidance and specifications for the safe and sustainable use of information and communication technology (ICT), including ICT products (e.g., mobile phones), equipment (e.g., adaptors, cables) and installation (e.g., small base stations, data centers).[20]

- *ITU-T SG20: Internet of things (IoT) and smart cities and communities (SC&C)*
ITU-T Study Group 20 (SG20) develops international standards (ITU-T Recommendations) providing commonly agreed guidance for implementing the Internet of Things (IoT) and its applications, as well as smart cities and communities. Its work supports digital transformation in both urban and rural areas enabled by solutions in fields such as IoT, digital twins, and artificial

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[16] https://www.iso.org/committee/45020.html, last viewed on 09.10.2023

[17] https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:20486, last viewed on 09.10.2023

[18] https://www.iso.org/committee/6483279.html, last viewed on 09.10.2023

[19] https://www.itu.int/en/ITU-T/studygroups/2022-2024/Pages/default.aspx, last viewed on 09.10.2023

[20] https://www.itu.int/en/ITU-T/studygroups/2022-2024/05/Pages/default.aspx, last viewed on 09.10.2023

intelligence. Standards developed by SG20 enable the coordinated deployment of IoT and address IoT implementation challenges related to interoperability, big data, and architectural frameworks and requirements for supporting various IoT systems.[21]

4.3. Standardization activities on European level

Of the standards that could be relevant for ALICIA, 48 documents at European level were included in the ALICIA dashboard. The main technical committees, which are responsible for these standards, are listed in Table 16 and are described in the following. Only TCs that published more than five standards of the ones included in the dashboard, are listed and described below. In addition, relevant standards under development are listed below.

Table 16: Relevant standard setting organizations and TC's on European level.

TC	Title
CEN/TC 322	Equipment for making and shaping of metals – safety requirements
CLC/TC 65X	Industrial-process measurement, control and automation

4.3.1. CEN/TC 322

This CEN/TC deals with standardization topics in the field of safety of equipment for making of iron, steel and non-ferrous metals and their shaping by rolling, forging, and extruding as semi-finished or finished products.[22] The committee is divided into five working groups and is coordinated by DIN. This TC has published 12 European standards so far, however, currently there are no activities ongoing.

4.3.2. CLC/TC 65X

This TC supports, contributes, and coordinates the preparation of international standards for systems and elements used for industrial process measurement, control and automation at CENELEC level. Especially this TC deals with the integration of components and functions into such systems, including safety and security aspects. The work of the committee is closely coordinated with the IEC TC65 and its subcommittees.[23]
The committee is divided into four working groups and is coordinated by DKE.
The most relevant working group is listed in the following:
- *CLC/TC 65X/WG 02: Smart manufacturing*

CLC/TC 65X has published 506 European standards so far and currently works on 90 CENELEC standards. 89 documents of these are planned as a European adoption of international IEC documents.

4.4. Standardization activities on national level

Of the standards that could be relevant for ALICIA, 69 documents at German national level were included in the ALICIA dashboard. TC's that published more than five standards of the ones included in the dashboard, are listed and described below.

- *VDA Quality Management Center*
- *VDI Society Production and Logistics*

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[21] https://www.itu.int/en/ITU-T/about/groups/2022-2024/Pages/sg20.aspx, last viewed on 09.10.2023

[22] https://standards.cencenelec.eu/dyn/www/f?p=205:7:0::::FSP_ORG_ID:6303&cs=1BAAF3815BC2B20CFBF731F31B904BF67, last viewed on 09.10.2023

[23] https://standards.cencenelec.eu/dyn/www/f?p=305:7:0:25:::FSP_ORG_ID,FSP_LANG_ID:1257871, last viewed on 09.10.2023

- *Verband Deutscher Maschinen- und Anlagenbau e.V.*
- *VDI/VDE Society Measurement and Automation*

4.4.1. VDA Quality Management Center

The Quality Management Centre (QMC) in German Association of the Automotive Industry e.V. (VDA) is dedicated to the development of methods and systems of quality management systems for the automotive industry. All car manufacturers producing in Germany as well as a representative selection of automotive suppliers are represented in the QMA by their QM management and the VDA by its management.[24]

4.4.2. VDI Society Production and Logistics

The association of German Engineers (VDI) supports engineers by creating a standardized basis and developing national standards that are practice-oriented and technical. They publish up to 250 VDI-guidelines per year.[25]

4.4.3. Association of German Mechanical and Plant Engineering

The Association of German Mechanical and Plant Engineering (VDMA) is the largest network organization and supports the machinery and equipment manufacturing industry in Germany and Europe. The association represents the common economic, technical, and scientific interests of this industry.[26] Through the DIN Mechanical Engineering Standards Committee (NAM), the VDMA promotes the competitiveness of the mechanical engineering industry. This Standards Committee could be of interest for ALICIA. In addition, the Standardization Department coordinates the preparation of VDMA specifications.[27]

4.4.4. VDI/VDE Society Measurement and Automation Control

Measurement and automation technology is effective in reducing the power requirements of electronic devices as well as in the measurement and control optimization of large chemical plants. The group of the Association for Electrical, Electronic & Information Technologies (VDE) deals with topics such as manufacturing or energy technology, environmental plants, traffic systems, building automation or medical technology.[28] The group is active in developing rules and regulations as well as national standards.

4.5. Standards related to ALICIA

In this section an overview is given about the most important standards (top 25) for the identified and most relevant areas of the project. The top 25 standards contain the most keywords per area either in the abstract, title, or search terms. The list of all relevant standards can be found in annex 3. In addition, the responsible technical committee of each standard is listed. In the upcoming month, the ALICIA partners will be asked which standards they use for their work in the project. If there are standards that they would like to use but do not have access, DIN will make them available.

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[24] https://vda-qmc.de/en/ueber-uns/gremien/, last viewed on 10.10.2023

[25] https://www.vdi.de/en/home, last viewed on 10.10.2023

[26] https://www.vdma.org/association, last viewed on 10.10.2023

[27] https://www.vdma.org/technical-rules-standards, last viewed on 10.10.2023

[28] https://www.vdi.de/tg-fachgesellschaften/vdi-gesellschaft-mess-und-automatisierungstechnik, last viewed on 10.10.2023

4.5.1. Area "Circular Economy"

Circular economy is a highly innovative topic and awareness regarding sustainability is increasing constantly. As the project is part of the call " CLIMATE NEUTRAL, CIRCULAR AND DIGITISED PRODUCTION 2022" and the topic "Digital tools to support the engineering of a Circular Economy" within the Horizon Europe Framework Program, part of the ALICIA standardization landscape should address circular economy.

There are a lot of new standards in the field of circular economy, especially from the year 2023. Table 17 lists the most relevant standards for ALICIA. All relevant standards in the field of circular economy can be found in appendix 3.

Table 17: List of top 25 standards relevant in the area of "circular economy", cells marked in blue represent standards under development.

Document number	Title	Publication date	Author
ISO 14007	Environmental management - Guidelines for determining environmental costs and benefits	2019-10-00	ISO/TC 207
ISO 14009	Environmental management systems - Guidelines for incorporating material circulation in design and development	2020-12-00	ISO/TC 207
ISO/TS 14027	Environmental labels and declarations - Development of product category rules	2017-04-00	ISO/TC 207
ISO 14045	Environmental management - Eco-efficiency assessment of product systems - Principles, requirements and guidelines	2012-05-00	ISO/TC 207
ISO 14046	Environmental management - Water footprint - Principles, requirements and guidelines	2014-08-00	ISO/TC 207
ISO/TR 14047	Environmental management - Life cycle assessment - Illustrative examples on how to apply ISO 14044 to impact assessment situations	2012-06-00	ISO/TC 207
ISO/TR 14049	Environmental management - Life cycle assessment - Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis	2012-06-00	ISO/TC 207
ISO/TS 14072	Environmental management - Life cycle assessment - Requirements and guidelines for organizational life cycle assessment	2014-12-00	ISO/TC 207
ISO/TS 14074	Environmental management - Life cycle assessment - Principles, requirements and guidelines for normalization, weighting and interpretation	2022-11-00	ISO/TC 207
ISO 20140-1	Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles	2019-09-00	ISO/TC 184
ISO 20140-2	Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 2: Environmental performance evaluation process	2018-08-00	ISO/TC 184
ISO 20140-5	Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 5: Environmental performance evaluation data	2017-04-00	ISO/TC 184
ISO 26000	Guidance on social responsibility	2010-11-00	ISO/TMBG Technical Management Board - Groups

Document number	Title	Publication date	Author
ISO/DIS 59004	Circular Economy - Terminology, Principles and Guidance for Implementation	2023-04-00	ISO/TC 323
ISO/DIS 59020	Circular economy - Measuring and assessing circularity	2023-04-00	ISO/TC 323
ITU-T L.1022	Circular economy: Definitions and concepts for material efficiency for information and communication technology	2019-10-00	ITU International Telecommunication Union
ITU-T L.1023	Assessment method for circular scoring	2020-09-00	ITU International Telecommunication Union
prEN IEC 63366	Product category rules for life cycle assessment of electrical and electronic products and systems.	2023-03-00	CLC/TC 111X
EN 50693	Product category rules for life cycle assessments of electronic and electrical products and systems	2019-08-00	CLC/TC 111X
CWA 17807	Dismantling methods and protocols in a Circular Economy Framework - Composite recovery in the automotive industry	2021-10-00	CEN European Committee for Standardization
VDI 4431	Life-cycle management in the manufacturing industry	2001-07-00	VDI Society Energy and Environment
DIN SPEC 91472	Remanufacturing (Reman) - Quality classification for circular processes	2023-06-00	DIN SPEC (PAS, CWA)

4.5.2. Area "Industry"

In the field of "industry" a lot of relevant standards for ALICIA exist.
Table 18 lists the most relevant standards for ALICIA in the industry context. All relevant standards in the field of industry can be found in the annex 3.

Table 18: List of top 25 standards relevant in the area of "industry".

Document number	Title	Publication date	Author
ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction	2010-11-00	ISO/TC 199
ISO 16100-3	Industrial automation systems and integration - Manufacturing software capability profiling for interoperability - Part 3: Interface services, protocols and capability templates	2005-12-00	ISO/TC 184
ISO 16100-5	Industrial automation systems and integration - Manufacturing software capability profiling for interoperability - Part 5: Methodology for profile matching using multiple capability class structures	2009-03-00	ISO/TC 184
ISO 16300-1	Automation systems and integration - Interoperability of capability units for manufacturing application solutions - Part 1: Interoperability criteria of capability units per application requirements	2018-10-00	ISO/TC 184
ISO 16300-3	Automation systems and integration - Interoperability of capability units for manufacturing application solutions - Part 3: Verification and validation of interoperability among capability units	2017-10-00	ISO/TC 184
ISO 16156	Machine-tools safety - Safety requirements for the design and construction of work holding chucks	2004-02-00	ISO/TC 39
ISO 17916	Safety of thermal cutting machines	2016-03-00	ISO/TC 44

Document number	Title	Publication date	Author
ISO/TR 18161	Automation systems and integration - Applications integration approach using information exchange requirements modelling and software capability profiling	2013-07-00	ISO/TC 184
ISO/IEC TS 33073	Information technology - Process assessment - Process capability assessment model for quality management	2017-11-00	ISO/IEC JTC 1/SC 7
IEC 62541-7	OPC unified architecture - Part 7: Profiles	2020-06-00	IEC/SC 65E
EN 614-1+A1	Safety of machinery - Ergonomic design principles - Part 1: Terminology and general principles	2009-02-00	CEN/TC 122
CEN ISO/TR 22100-1	Safety of machinery - Relationship with ISO 12100 - Part 1: How ISO 12100 relates to type-B and type-C standards (ISO/TR 22100-1:2021)	2021-02-00	CEN/TC 114
EN 1550+A1	Machine-tools safety - Safety requirements for the design and construction of work holding chucks	2008-07-00	CEN/TC 143
EN 14656+A1	Safety of machinery - Safety requirements for extrusion presses for steel and non-ferrous metals	2010-04-00	CEN/TC 322
EN 14677	Safety of machinery - Secondary steelmaking - Machinery and equipment for treatment of liquid steel	2008-04-00	CEN/TC 322
EN 14681+A1	Safety of machinery - Safety requirements for machinery and equipment for production of steel by electric arc furnaces	2010-04-00	CEN/TC 322
EN 16774	Safety of machinery - Safety requirements for steel converter and associated equipment	2016-04-00	CEN/TC 322
CWA 17907	European Connected Factory Platform for Agile Manufacturing Interoperability (EFPFInterOp)	2022-11-00	CEN European Committee for Standardization
DIN EN 60204-33	Safety of machinery - Electrical equipment of machines - Part 33: Requirements for semiconductor fabrication equipment (IEC 60204-33:2009, modified); German version EN 60204-33:2011	2011-11-00	German Commission for Electrical, Electronic and Information Technologies of DIN and VDE
DIN SPEC 16589	Information technology - Automatic identification and data capture techniques - Traceability Pointer to Process	2018-07-00	Information Technology and selected IT Applications Standards Committee
VDI/VDE 2193 Blatt 1	Language for I4.0 Components - Structure of messages	2020-04-00	VDI/VDE Society
VDI/VDE 2193 Blatt 2	Language for I4.0 components - Interaction protocol for bidding procedures	2020-01-00	VDI/VDE Society
VDI 3405 Blatt 6.2	Additive manufacturing processes - User safety on operating the manufacturing facilities - Laser sintering of polymers	2021-04-00	VDI Society Production and Logistics
VDI/VDE 3850 Blatt 3	Development of usable user interfaces for technical plants - Features, design and applications of user interfaces with touchscreen	2015-11-00	VDI/VDE Society Measurement and Automation
VDI 4499 Blatt 4	Digital factory - Ergonomic representation of humans in the digital factory	2015-03-00	VDI Society Production and Logistics

4.5.3. Area "Automation"

Automation is the biggest field within ALICIA, with 187 standards identified as relevant. As for this area of standards no further keywords were given, no further restrictions could be made. For this reason, it was not possible to list the most important standards (top 25) as was done for the other areas. The full list can be found in appendix 3.

4.5.4. Area "Digitalization"

In the field of "digitalization", 56 standards were identified as relevant for ALICIA.

Table 19 lists the most relevant standards for ALICIA according to the keywords in the context of digitalization. All relevant standards in this field can be found in appendix 3.

Table 19: List of top 25 standards relevant in the area of "digitalization", cells marked in blue represent standards under development.

Document number	Title	Publication date	Author
ISO 14306	Industrial automation systems and integration - JT file format specification for 3D visualization	2017-11-00	ISO/TC 184
ISO 16100-3	Industrial automation systems and integration - Manufacturing software capability profiling for interoperability - Part 3: Interface services, protocols and capability templates	2005-12-00	ISO/TC 184
ISO 16100-5	Industrial automation systems and integration - Manufacturing software capability profiling for interoperability - Part 5: Methodology for profile matching using multiple capability class structures	2009-03-00	ISO/TC 184
ISO 18828-5	Industrial automation systems and integration - Standardized procedures for production systems engineering - Part 5: Manufacturing change management	2019-01-00	ISO/TC 184
ISO 23247 series (part 1-4)	Automation systems and integration - Digital twin framework for manufacturing	2021-10-00	ISO/TC 184
ISO/IEC 30162	Internet of Things (IoT) - Compatibility requirements and model for devices within industrial IoT systems	2022-02-00	ISO/IEC JTC 1/SC 41
ISO/IEC TR 30166	Internet of things (IoT) - Industrial IoT	2020-04-00	ISO/IEC JTC 1/SC 41
ISO/IEC 30181 ED1	Internet of Things (IoT) - Functional architecture for resource ID interoperability	2023-03-00	ISO/IEC JTC 1/SC 41
IEC 62541-7	OPC unified architecture - Part 7: Profiles	2020-06-00	IEC/SC 65E
IEC 62832-3	Industrial-process measurement, control and automation - Digital Factory framework - Part 3: Application of Digital Factory for life cycle management of production systems	2020-10-00	IEC/TC 65
IEC 63278-2 ED1	Asset Administration Shell for Industrial Applications - Part 2: Information meta model	2023-03-00	IEC/TC 65
IEC/PAS 63088	Smart manufacturing - Reference architecture model industry 4.0 (RAMI4.0)	2017-03-00	IEC/TC 65
IEC PAS 63485 ED1	Intelligent Information Request and Delivery Specification (iiRDS) - A process model for information architecture	2023-02-00	IEC/TC 3
ETSI GR CIM 017 V 1.1.1	Context Information Management (CIM) - Feasibility of NGSI-LD for Digital Twins	2022-12-00	ETSI/ISG CIM Cross-cutting Context Information Management

Document number	Title	Publication date	Author
CWA 17907	European Connected Factory Platform for Agile Manufacturing Interoperability (EFPFInterOp)	2022-11-00	CEN European Committee for Standardization
VDI/VDE 2193 Blatt 1	Language for I4.0 Components - Structure of messages	2020-04-00	VDI/VDE Society Measurement and Automation
VDI/VDE 2193 Blatt 2	Language for I4.0 components - Interaction protocol for bidding procedures	2020-01-00	VDI/VDE Society Measurement and Automation
VDMA 40210	OPC UA for Geometric Measurement Systems	2022-04-00	Verband Deutscher Maschinen- und Anlagenbau e. V.
VDI 4499 Blatt 2	Digital factory - Digital Factory Operations	2011-05-00	VDI Society Production and Logistics
VDI 4499 Blatt 3	Digital factory - Data management and system architectures	2023-02-00	VDI Society Production and Logistics
VDI 4499 Blatt 4	Digital factory - Ergonomic representation of humans in the digital factory	2015-03-00	VDI Society Production and Logistics

The following standards were evaluated by TU Graz as potentially highly relevant.
-   ISO 16100-3:2005
-   ISO 16100-5:2009
-   ISO 23247 series (part 1-4)
-   ISO/IEC 30162

Especially the interoperability aspect is highly relevant for ALICIA. The standards ISO 16100-3 and ISO 16100-5 could contribute to greater interoperability of software in the current applied MaRCO Ontology in WP1, and the ISO/IEC 30162 could be useful for ensuring greater interoperability of equipment. Further, the standard series ISO 23247 (part 1-4) could be relevant for WP3 and WP4 in the context of the creation of a digital twin in a manufacturing environment.

In addition to the provided list of standards the following standards were evaluated by ECI as potentially highly relevant:
The document *VDI/VDE 3711:2020 - Input and transfer of maintenance information for condition monitoring - Digitisation of offline information* could potentially be a great asset towards identifying and developing a structure to generically assess and collect maintenance information for used assets which are to be included in the ALICIA marketplace. Even though this standard specifically focuses on condition monitoring, the digitization of offline information relating to maintenance is a relevant part of ensuring asset maintenance aspects are accurately represented in ALICIA.
In addition, the standard *ISO/TS 15926-12 - Industrial automation systems and integration - Integration of life-cycle data for process plants including oil and gas production facilities - Part 12: Life-cycle integration ontology represented in Web Ontology Language (OWL)* could potentially be important to identify how to properly integrate life cycle aspects of asset data models and asset data into ontologies within ALICIA. These ontologies don't necessarily focus on process plants as stated in the standard, but the information contained within could potentially have relevance for the integration of life cycle data in non-process plant related ontologies.

The following standards are already used within ALICIA:

Table 20: List of standards already used within ALICIA, cells marked in blue represents standards under development.

Document number	Title	Subcommittee
IEC/PAS 63088	Smart manufacturing -Reference architecture model industry 4.0 (RAMI4.0)	IEC/TC 65
FprEN IEC 63278-1	Asset Administration Shell for industrial applications - Part 1: Asset Administration Shell structure	CLC/TC 65X
IEC 63278-2	Asset Administration Shell for Industrial Applications-Part 2: Information metamodel	IEC/TC 65
DIN SPEC 27070	Requirements and reference architecture of a security gateway for the exchange of industry data and services	DIN e.V.
DIN SPEC 91345	Reference Architecture Model Industrie 4.0 (RAMI4.0)	DIN e.V.
DIN SPEC 16593-1	RM-SA -Reference Model for Industrie4.0 Service Architectures -Part 1: Basic Concepts of an Interaction-based Architecture	Digital platform – DIN e.V.

The standards listed in Table 20 describe the technologies RAMI 4.0 and Asset Administration Shell, which are key technologies in enabling the ALICIA Plug & Produce Middleware, which is addressed in WP4 of ALICIA, to be compliant to industry standards and ensuring state of the art implementation of the middleware components. The technologies partially described in these standards are used to implement the ALICIA middleware based on the most recent and cutting-edge industry 4.0 and smart manufacturing concepts. The Asset Administration Shell is the central technology of the middleware, enabling vendor independent, interoperable communication to production assets and unifying interfaces towards their data structures and functionalities. RAMI 4.0 is used as a reference architecture model for the middleware to ensure it is grounded in the reality of what the industry is moving towards, ensuring compliance with the latest technologies. These standards are used within ALICIA for the digital representation of assets and for connecting legacy equipment to the Plug & Produce middleware. Following data formats, information models, schemes, and transmission protocols are used for information exchange between and within the digital services offered on the platform:

- RESTful API
- OPC-UA (https://opcfoundation.org/about/opc-technologies/opc-ua/)
- MQTT (https://mqtt.org/)
- AutomationML (https://www.automationml.org/)
- AMQP (Advanced Message Queuing Protocol) (https://www.amqp.org/)
- MTConnect (https://www.mtconnect.org/)
- EUROMAP (https://www.euromap.org/)
- IDS (International Data Spaces) (https://internationaldataspaces.org/)
- JSON (https://www.json.org/json-en.html)
- XML (https://www.w3.org/XML/Core/)
- RDF (https://www.w3.org/RDF/)

The standards IEC/PAS 63088, FprEN IEC 63278-1, IEC 63278-2 and DIN SPEC 91345 (RAMI 4.0) are used as reference for the modelling and development of the Asset Administration Shell (AAS) in ALICIA. RAMI 4.0 and AAS enable a fully mapped Digital Twin representation in Industry 4.0. Also, ALICIA considers both RAMI 4.0 and AAS for Digital Twin representation of manufacturing equipment. DIN SPEC 27070 International Data Spaces (IDS) is used for secure data exchange using IDS connectors between ALICIA architecture components. This standard was created for secure cross-company exchange of industrial manufacturing data and describes the requirements and reference architecture of a security gateway. The Marketplace of MARKET 4.0, which is utilized and extended in ALICIA, already makes use of IDS connectors that will allow the ALICIA Platform components to exchange data securely.

4.5.5. Area "Quality Management"

Quality Management is an essential topic, in general, but especially in the industrial context. Also for ALICIA it is important to consider the currently existing standards in the field of quality management in order to meet the current state-of-the-art. 25 standards are of relevance for ALICIA in this context. They are listed in Table 21.

Table 21: List of top 25 standards relevant in the area of "quality management".

Document number	Title	Publication date	Author
ISO 9000	Quality management systems - Fundamentals and vocabulary	2015-09-00	ISO/TC 176
ISO 9001	Quality management systems - Requirements	2015-09-00	ISO/TC 176
ISO 14001	Environmental management systems - Requirements with guidance for use	2015-09-00	ISO/TC 207
ISO 14004	Environmental management systems - General guidelines on implementation	2016-03-00	ISO/TC 207
ISO 14031	Environmental management - Environmental performance evaluation - Guidelines	2021-03-00	ISO/TC 207
ISO 14033	Environmental management - Quantitative environmental information - Guidelines and examples	2019-02-00	ISO/TC 207
ISO/IEC TS 33073	Information technology - Process assessment - Process capability assessment model for quality management	2017-11-00	ISO/IEC JTC 1/SC 7
IEC 62309	Dependability of products containing reused parts - Requirements for functionality and tests	2004-07-00	IEC/TC 56
IEC TS 63164-1	Reliability of industrial automation devices and systems - Part 1: Assurance of automation devices reliability data and specification of their source	2020-02-00	IEC/TC 65
IEC TR 63164-2	Reliability of industrial automation devices and systems - Part 2: System reliability	2020-07-00	IEC/TC 65
ISO/IEC/IEEE 90003	Software engineering - Guidelines for the application of ISO 9001:2015 to computer software	2018-11-00	ISO/IEC JTC 1/SC 7
EN 100114-6	Rule of procedure 14: Quality assessment procedures - Part 6: Technology approval of electronic component manufacturers	1996-12-00	CLC/TC CECC/WG-QAP
EN 100114-6/A1	CECC Quality assessment procedure for electronic components - Part 6: Technology approval of manufacturers; Amendment A1	1999-02-00	CLC/TC CECC/WG-QAP
VDA Volume 2	Quality Management in the Automotive Industry - Securing the Quality of Supplies - Production process and product approval (PPA)	2020-04-00	VDA QMC
VDA Volume 3 Part 2	Quality Management in the Automotive Industry - Reliability Assurance of Car Manufacturers and Suppliers - Reliability methods and tools	2016-05-00	VDA QMC
VDA Volume 4 Section 2	Quality Management in the Automotive Industry - Quality Assurance in the Process Landscape - Section 2: Risk Analyses - Fault Tree Analysis (FTA), Failure Mode and Effects Analysis (FMEA), SWOT-Analysis (Strengths, Weaknesses, Opportunities, Threats)	2020-08-00	VDA QMC
VDA Volume 4 Section 3	Quality Management in the Automotive Industry - Quality Assurance in the Process Landscape - Section 3: Methods - Design for Manufacturing and Assembly (DFMA), Digital Mock-Up (DMU), Design of Experiments (DoE) – Trial Methodology, Manufacturing Feasibility Analysis, POKA YOKE, Quality Function Deployment (QFD), TRIZ, Economical Process	2020-08-00	VDA QMC

Document number	Title	Publication date	Author
	Design and Process Control, 8D Method, 5 Why Method, Selection of Preventive Quality Management Methods		
VDA Volume 4 Section 4	Quality Management in the Automotive Industry - Quality Assurance in the Process Landscape - Section 4: Process Models - Six Sigma, Design for Six Sigma (DFSS), Industrial Tolerance Process	2020-08-00	VDA QMC
VDA Volume 5	Quality Management in the Automotive Industry - Measurement and Inspecion Processes - Capability, Planning and Management	2021-07-00	VDA QMC
VDA Volume 5 Praxishandbuch	Quality Management in the Automotive Industry - VDA 5 Practical Guide	2022-04-00	VDA QMC
VDA Volume 5.1	Quality Management in the Automotive Industry - Traceable inline metrology in car body manufacture; Supplement volume to VDA 5, Capability of measurement processes	2013-00-00	VDA QMC
VDA Volume 5.2	Quality Management in the Automotive Industry - Capability of Measurement Processes for the Torque Inspection on Bolted Joints	2013-00-00	VDA QMC
VDA Volume 19 Part 2	Quality Management in the Automotive Industry - Technical cleanliness in assembly - Environment, logistics, personnel and assembly equipment	2010-10-00	VDA QMC
IATF 16949	IATF 16949: Quality management system requirements for automotive production and relevant service parts organisations	2016-10-00	VDA QMC
VDA Volume Qualitätsbezogene Kosten	Quality Management in the Automotive Industry - Quality-related costs - Failure costs and failure prevention costs, scope and implementation	2015-04-00	VDA QMC

The standard IATF 16949 is potentially of great interest to ALICIA in the area of quality management and to make sure that ALICIA is aligned with the state-of-the-art. This is because it places a particular focus on product and process development and includes the planning, reviewing and validation of designs, as well as the consideration of error risks and error prevention through the use of Failure Mode and Effects Analysis (FMEA). These aspects are crucial to developing innovative, high-quality, and safe products that meet customer expectations and legal requirements.

Although the standard contains specific requirements that only apply to the automotive industry, ISO 9001 is a general standard for quality management systems. Nevertheless, the specific requirements of ISO 9001 certified organizations can be met easily, as many requirements from IATF 16949 are based on ISO 9001.[29]

The use case partners (Continental & Comau), who represent the automotive industry, are therefore planning to use metrics from IATF 16949 for the digital services Digital Shadow / Digital Twin to be able to evaluate and to compare the machine condition in a standardized manner. The KPIs of the use case partners are shown in

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[29] www.smct-management.de/iatf-16949/, last viewed on 20.11.2023

Table 22 and Table 23.

Table 22: KPIs from the use case partner Comau

External KPIs	Technical efficiency
	Availability
	Cycle Time
	Quality of production
	Mean Time Between Failures (MBTF)
	Mean Time To Repair (MTTR)

Table 23: KPIs from the use case partner Continental

Subject	KPI
Engineering process	Budget
	Time
Line Performance	Cycle Time
	Units produced
	Overall equipment efficiency
Machine	Technical availability

ALICIA should also consider the volumes and guidelines of VDA, which support quality assurance, development, and production in the automotive industry. In many cases, they are closely linked to the international standard IATF 16949.[30] These aspects could play an important role in ALICIA's "In-Factory-Use-Phase" services to support the factory owner during installation, commissioning, and production. The VDA Volume 4 Section 2-4 contains, among other things, useful tools from Six Sigma and Design for Six Sigma (DfSS) that can positively enrich this phase. Six Sigma represents a scientific quality management method with the aim of reducing or optimizing errors and error performance in existing processes or products.

The method combines the following basic principles:
- a structured and standardized approach,
- process orientation,
- a holistic view of the customer needs,
- evidence of the cause-and-effect chain,
- integration into the work task, and
- support during application (means training company employees to become Six Sigma experts).

The five phases of a classic Six Sigma project are shown below:
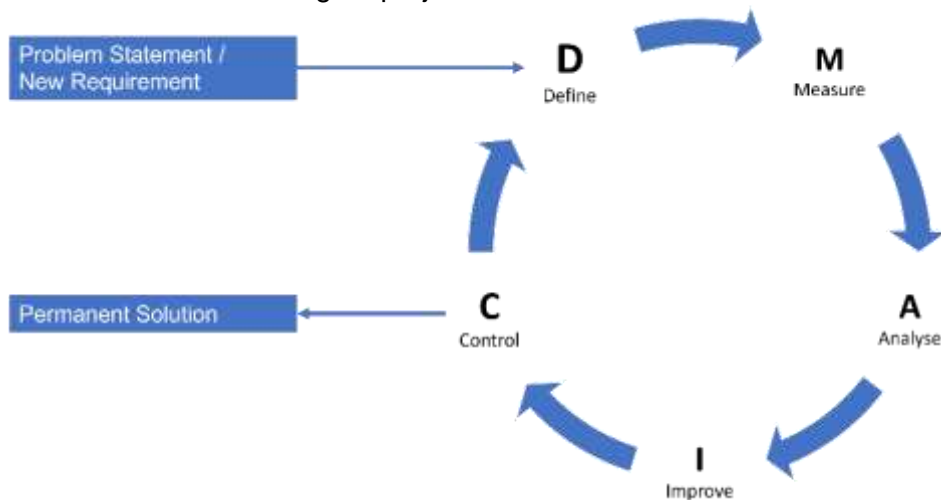

Figure 11: DMAIC-cycle as an expression of continuous improvement[31]

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[30] www.smct-management.de, last viewed on 20.11.2023

[31] Back, S., & Weigel, H. (2014). *Design for Six Sigma*. Regensburg: Hanser Fachbuchverlag

DfSS is a universal approach used for method-supported development in the product development process. As data-based decisions are also made here, numerous methods and tools from the classic DMAIC can be used in the product development process.[31]

4.5.6. Other Areas (e.g. social, ethical, artificial intelligence)

The following Table 24 shows a list of 12 standards relevant in terms of social, ethical or artificial intelligence, which might be relevant for ALICIA. Especially in the context of WP7, where the focus is on social, ethical and environmental assessments, these standards could be helpful.

Table 24: List of standards relevant in terms of social, ethical or artificial intelligence, cells marked in blue represents standards under development.

Document number	Title	Publication date	Author
ISO/IEC TR 24027	Information technology - Artificial intelligence (AI) - Bias in AI systems and AI aided decision making	2021-11-00	ISO/IEC JTC 1/SC 42
ISO/IEC TR 24368	Information technology - Artificial intelligence - Overview of ethical and societal concerns	2022-08-00	ISO/IEC JTC 1/SC 42
ISO/IEC FDIS 24392	Cybersecurity - Security reference model for industrial internet platform (SRM- IIP)	2023-04-00	ISO/IEC JTC 1/SC 27
ISO 26000	Guidance on social responsibility	2010-11-00	ISO/TMBG Technical Management Board - Groups
ISO/IEC 38507	Information technology - Governance of IT - Governance implications of the use of artificial intelligence by organizations	2022-04-00	ISO/IEC JTC 1/SC 40
ISO/DIS 59020	Circular economy - Measuring and assessing circularity	2023-04-00	ISO/TC 323
IEC TR 63283-4 ED1	Industrial-process measurement, control and automation - Smart Manufacturing - Part 4: Recommendations for the usage of new technologies	2023-02-00	IEC/TC 65
ITU-T L Supplement 52	Computer processing, data management and energy perspective	2022-10-00	ITU International Telecommunication Union
EN 17161	Design for All - Accessibility following a Design for All approach in products, goods and services - Extending the range of users	2019-03-00	CEN/CLC/JTC 12
ETSI TS 103463-1 V 1.2.1	Access, Terminals, Transmission and Multiplexing (ATTM) - Sustainable Digital Multiservice Communities - Key Performance Indicators for Sustainable Digital Multiservice Areas - Part 1: Description of Key Performance Indicators	2020-05-00	ETSI/ATTM SDMC
VDI 2343 Blatt 7	Recycling of electrical and electronical equipment - Re-use	2014-12-00	VDI Society Energy and Environment
VDI 4605	Evaluation of sustainability	2017-10-00	VDI Society Energy and Environment

4.5.7. Consortial standards

There are also some consortial standards (see description in 2.3.4), which might be relevant for ALICIA. The most important organizations in the context of ALICIA which develop those consortial standards are described in the following.

IDTA

The industrial Digital Twin Association e.V. (IDTA) deals with the technology related to digital twins in the context of industry 4.0. The IDTA designs Asset Administration Shells and provides specifications in this field in order to allow the industry creating a digital twin[32]. Published open source software serves as basis for the industry, to create their own Asset Administration Shells.

OASIS

The Organization for the Advancement of Structured Information Standards (OASIS) is a global organization dealing with standardization projects for cybersecurity, blockchain, IoT, emergency management, cloud computing, legal data exchange, etc. [33] With MQTT OASIS developed a standard messaging protocol for the Internet of Things (IoT). It is designed as an extremely lightweight publish/subscribe messaging transport that is ideal for connecting remote devices with a small code footprint and minimal network bandwidth. MQTT today is used in a wide variety of industries, such as automotive, manufacturing, telecommunications, oil and gas, etc.[34]

MTConnect Institute

The MTConnect Institute is a not-for-profit standards development organization for the MTConnect standard. Companies and research organizations from manufacturing including automotive, aerospace, medical, and other industries as well as software developers, system integrators, and research organizations supporting those industries are member of this Institute.[35] The MTConnect standard (ANSI/MTC1.4-2018) is a domain specific semantic vocabulary for manufacturing equipment. Developers and system integrators use this information model to provide structured, contextualized data with no proprietary format. MTConnect data sources include things like production equipment, sensor packages, and other hardware.

GAIA-X, Catena-X, and Manufacturing-X standards

GAIA-X is a European cloud project whose core objective is to develop a secure and trustworthy standard for a cloud infrastructure. The architecture of GAIA-X is based on the principle of decentralization. GAIA-X is the interaction of numerous individual platforms that all follow a common standard – the GAIA-X standard. The aim is to create a data infrastructure that improves both the digital sovereignty of users of cloud services and the scalability and competitive position of European cloud providers.[36]

In the automotive industry, the initiative "Catena-X" has set out to create a collaborative and open data ecosystem. Its goal is to enhance collaboration among various stakeholders along the supply chain, facilitate the integration of data and processes, and ensure data sovereignty. The development and adoption of common standards ensure interoperability, enabling a unified implementation of core processes such as circular economy practices, quality management, or CO_2 reporting.[37] GAIA-X and IDSA envisage a data ecosystem with data spaces from various industries. In this context, Catena-X can be classified as one of these data spaces within the GAIA-X ecosystem, thereby covering the data space of the automotive industry.[38]

The developed standards are consortial standards. The full list of currently published Catena-X standards can be accessed on the webpage of the Catena-X project.[39]

In October 2023, 56 Catena-X standards were published. The documents deal with the following topics related to the automotive industry:

- Data Discovery Services
- Semantics
- Data Chains
- Sovereign Data Exchange

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[32] https://industrialdigitaltwin.org/en/, last viewed on 20.11.2023

[33] https://www.oasis-open.org/org/, last viewed on 10.10.2023

[34] https://mqtt.org/, last viewed on 10.10.2023

[35] https://www.mtconnect.org/, last viewed on 10.10.2023

[36] https://gaia-x.eu/, last viewed on 10.10.2023

[37] www.catena-x.net/de, last viewed on 10.10.2023

[38] www.tributech.io, last viewed on 10.10.2023

[39] https://catena-x.net/de/standard-library, last viewed on 10.10.2023

- Product Lifecycle Management and Quality
- Sustainability
- Onboarding
- Business Partner Data Management
- Identity & Access Management
- Resiliency

Since October, 16 there is also an online live platform for collaboration within Catena-X.[40]

As the majority of the ALICIA platform's target user group and use case partners come from the automotive industry and industrial companies, such as Original equipment manufacturers (OEMs) (e.g. BMW, Mercedes, Volkswagen, etc.) as well as suppliers and service providers (e.g. Continental, Comau, ZF, etc.), and are already involved in Catena-X, informal standards from Catena-X could be important for ALICIA for strategic reasons to make the ALICIA platform more attractive to the market. This is because the existing concept for regulating data exchange ensures trust between data providers and data recipients. The Eclipse Data Space Connector (EDC) communication component, which implements the IDS standard and relevant protocols in connection with GAIA-X, was developed for this purpose.[37]
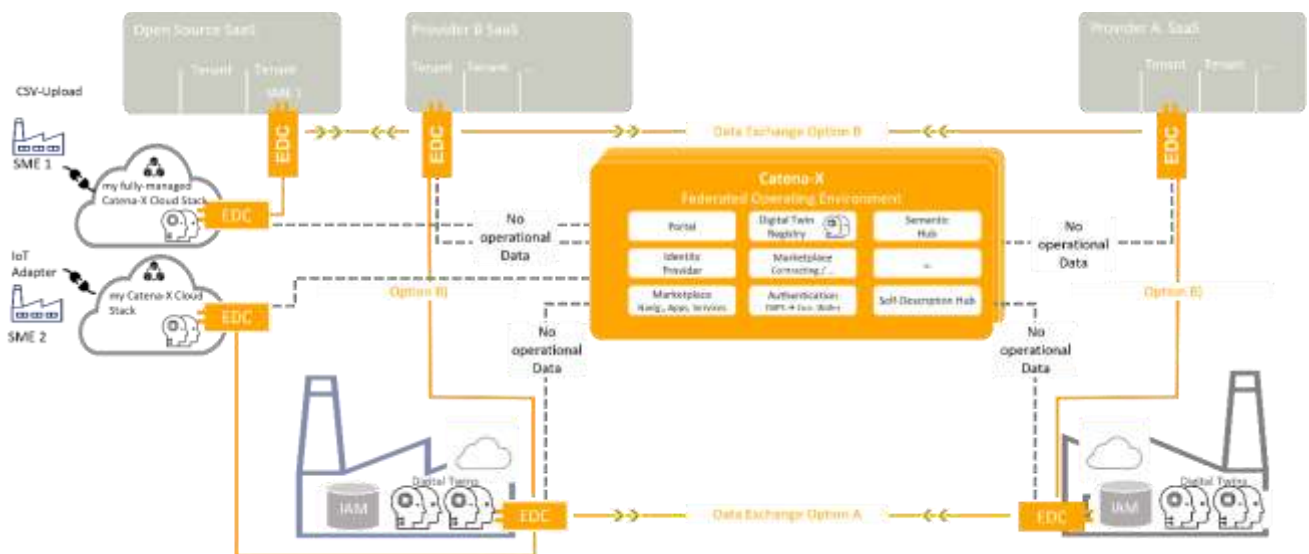
Figure 12: Data ecosystem according to Catena-X[41]

Catena-X serves as the foundation for other industrial sectors. Since the beginning of 2023, a new initiative, "Manufacturing-X," has emerged under the Industry 4.0 platform, which has been in existence since 2013, forming a network of companies, associations, unions, and research institutions. It is led by the German Federal Ministry for Economic Affairs and Climate Action and the Federal Ministry of Education and Research. The objective is to create a sovereign data space for the entire industry. This involves expanding the industry-centric approach of Catena-X to other industrial domains while aligning with the architecture and core services of Catena-X. Additional operator- and machinery-specific requirements, such as multilateral or real-time data exchange, will be incorporated. This development could be relevant for the ALICIA platform.[42]

At this point in the project, it is not possible to say which consortial standards from Catena-X, Manufacturing-X, etc. could be relevant for the work in ALICIA.

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[40] https://catena-x.net/en/news-dates/artikel/go-live, last viewed on 20.10.2023

[41] https://catena-x.net/de/angebote-standards/edc-die-zentrale-komponente-fuer-die-navigation, last viewed on 20.11.2023

[42] www.digitalstrategie-deutschland.de, last viewed on 20.11.2023

5. Summary and Conclusion

Generally, the present deliverable provides an overview of the standardization landscape related to ALICIA and summarizes the results of the first year from ALICIA in Task 7.5 - *Standardization*. The knowledge about existing standards is important for the project since it enables the development of solutions which are compliant with the latest standards and further paves the way for upcoming liaison activities with relevant technical committees. For this, a standards database in form of a dashboard was created, which includes 373 standards that could be relevant for the project. This dashboard provides the opportunity to search for specific standards and to identify standardization gaps. It is therefore used as the basis for the following activities in T7.5. Within this deliverable, the dashboard was used to describe the standardization activities on international and European level related to ALICIA. Focus was put on areas that have high relevance for the project. The next steps include to focus further on these areas to initiate targeted standardization activities. Besides listing relevant standards, this deliverable offers an overview of the TC's that are working on standards related to the project. Since the interaction with relevant standardization committees is envisaged within ALICIA, an overview of current work items of the most relevant TC's is provided. Within ALICIA the contribution to ongoing or the initiation of new standardization activities is sought. A workshop will be held to analyze the need for standardization and thus the existence of possible standardization gaps in connection with ALICIA's work. This will then lead directly to the initiation of standardization activities (see Figure 1). Altogether, through the work done in T7.5, awareness for standardization was raised throughout the consortium and the foundation was laid for the subsequent subtasks.

The following section shows the subtasks of standardization (see Figure 1) in detail and describes activities already carried out and planned for the near future within ALICIA:

Investigation of relevant standards
- *Already done:*
  - Identification of relevant standards → provided in the form of the standards dashboard
- *Planned*:
  - Continuous updates on the standardization landscape of ALICIA
  - Identification of standards which are used within ALICIA, providing relevant standards that are planned to be used within ALICIA

Standardization strategy
- *Planned*:
  - Identification of standardization needs/gaps within a workshop and further meetings to develop a strategy for further standardization activities

Standardization activities
- *Already done*:
  - national (German) mirror committees were informed about ALICIA → first exchange meeting with VDMA to identify the possibility for joint standardization activities
  - CEN-CENELEC-ETSI Coordination Group Smart Manufacturing was informed about ALICIA
  - Invitation to the next meeting of the German standardization committee „Ecodesign, in particular material efficiency of energy-related products" at 22.01.2024 in Berlin (NA 172-00-14 GA - joint working committee NAGUS/DKE)
- *Planned:*
  - Further information and exchange with relevant standardization committees on national, European, and international level
  - Identification of relevant ongoing standardization projects and decision how to contribute (e.g., liaison with relevant TCs)
  - Based on the identification of standardization needs/gaps initiation of standardization activities (e.g., liaison with relevant TCs, proposal for CWA)

Annex 1: Slides from the training "Basics on Standardization"

Basics on Standardisation

Training by DIN

04-11-2023

alicia – assembly lines in circulation

ALICIA – Project 101091577 – Horizon Europe

DIN Standards – well known

"A" Paper sizes

For 95 years standard paper sizes have been used by manufacturers, sellers and consumers alike. These DIN formats have been adopted by almost all countries in the world and are now defined in DIN EN ISO 216.

Traveling the world: the ISO container

250 million ISO standard freight containers travel the world each year. ISO 668 is an excellent example of the impact of international standardization.

Made for business: ISO 9001

Quality management ISO 9001 helps organizations improve their processes and ensures a high quality of products and services.

ALICIA – Project 101091577 – Horizon Europe

2

Standardisation

Standardisation is the activity of **establishing**, with regards to actual or potential **problems**, **provisions** for common and repeatable use, aimed at the achievement of the optimum degree of order in a given context.

Source: EN 45020:2006 Standardization and related activities - General vocabulary (ISO/IEC Guide 2:2004)

Why are standards important for R&I projects?

What are the results from standardisation?

Deliverable of the standardisation process is a document

✓ Voluntary
✓ Open to the public
✓ Broad participation
✓ State of the art
✓ Consistent

product

service and process

What can be standardised:

testing

terminology and symbols

quality and safety
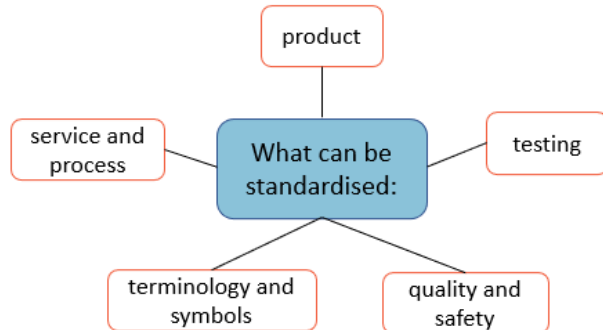
Standardisation deliverables

different types exist

Standard (e.g. ISO, EN, DIN, UNI)

Consensus

Public Engagement

Reliable & Acknowledged

Specification/Agreement (e.g. IWA, CWA , DIN SPEC, UNI Prassi di Riferimento (UNI PdR))

Flexible & Fast

Consortium Standard 🚫 often not publicly available

Level of Consensus

Time
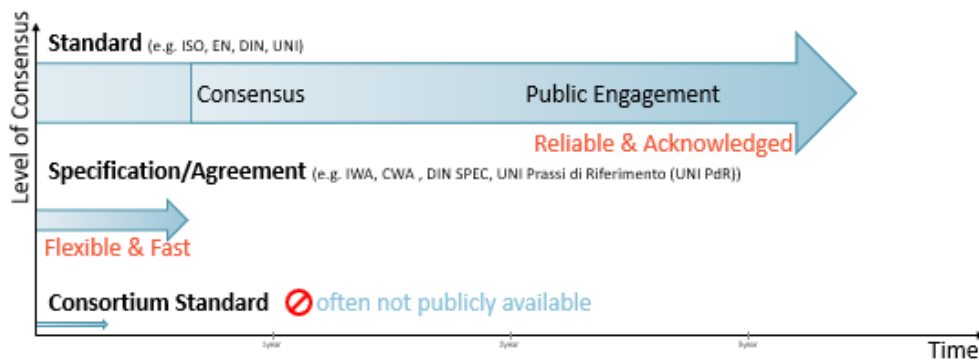
What are standards and specifications?

What is a standard?	What is a specification?
document that is approved by a recognized body and...	document agreed upon by the group of developers, which is designed to meet an immediate need and form the basis for future standardisation activities and...
• establishes a **common ground** • lays down **rules or guidlines** for activities or their results • creates **conformity** and order by **defining requirements** • developed by **all interested stakeholders** • produced by **consensus** • reflects the **state-of-the art**	• can be developed **outside the technical committee structure** • it is open to the **direct participation of anyone** • it offers **rapid** development opportunities • the **publication** within duration of project is possible

Standards are set by oneself; regulations come from „outside"!

Development of standards
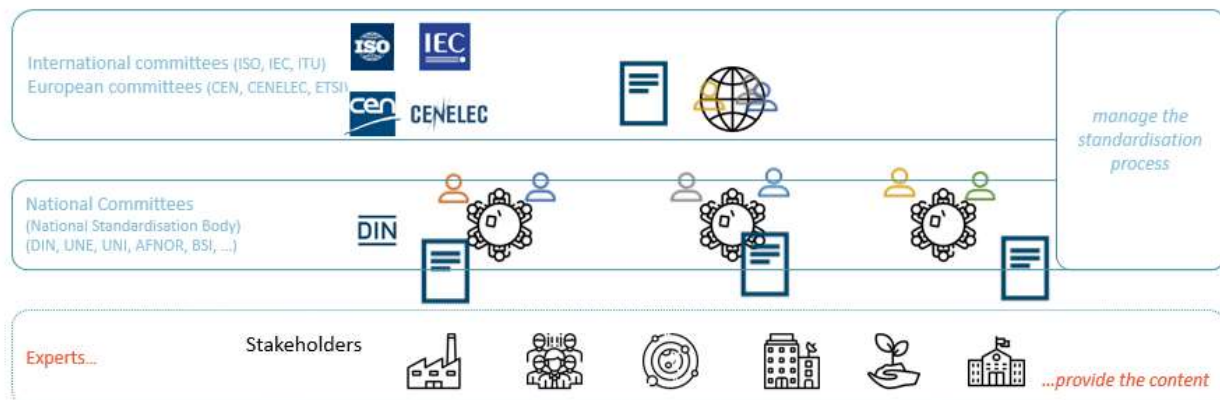
Development of a specification

| 1 | Initiation | 2 | Workshop phase | 3 | Specification/ Agreement |

Initiation
- by everyone
- project plan to inform the public
- create a workshop

Workshop phase
- development of the content
- publication

Specification/ Agreement

Public

Initiator with idea → Workshop creation → Development →

ISO – International Workshop Agreement
CEN – CEN Workshop Agreement
Italy (UNI) – Prassi di riferimento – PdR
Germany (DIN) – DIN SPEC
...
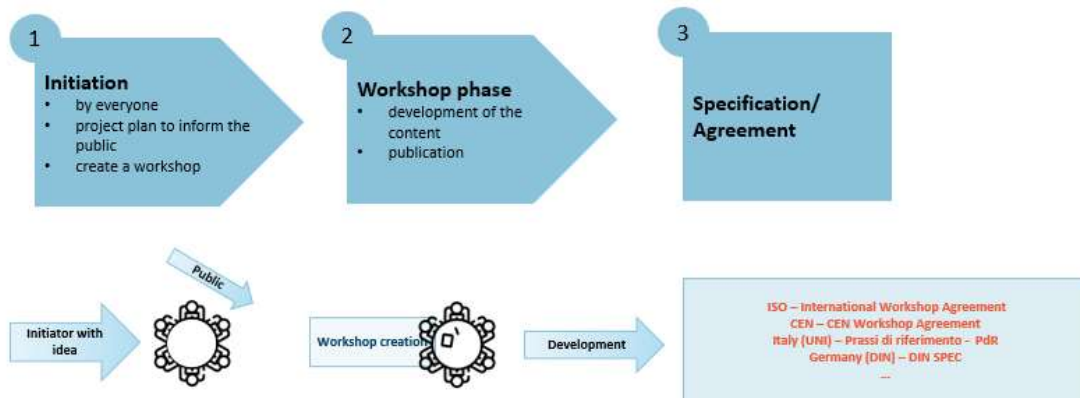
How can we use this for ALICIA?

TRL 3

WP1. Specification/System architecture, framework for capturing factory-owner requirements

WP2. AI-matchmaking Engine

WP4. Plug & Produce Middleware and Adaptors

WP3. Digital Shadow / Digital Twin

WP5. Marketplace

WP6. Test ALICIA digital tools on small scale, followed by demonstration in two industrial use-cases

WP7. Framework conditions/prep are commercial uptake post-project

- Ethical analysis
- Societal analysis (human centricity)
- Novel business models
- Worker training kit
- Standardisation

WP8. Manage Project, Disseminate, Exploit and Communicate

TRL 4
TRL 5
TRL 6

Participation – dissemination of ALICIA results

Contribution to ongoing standardisation activities	Developing new specifications
Liaison with Technical Committee	(Develop ideas through) identification of standardisation potential/needs in the couse of standardisation workshop
Taking part in discussions of relevant TCs/WGs	Develop the content together with other interested partners/parties
Commenting on draft standards	Publish CEN Workshop Agreement (CWA, Specification on EU level)

How we help you:

- Research of relevant standards

- Access to standards

- Liaisons with Technical Committees

- Identification of standardisation potentials

- Project management for your specification

Overview T7.5 Standardisation

Standards research

Standards potential

Standards development
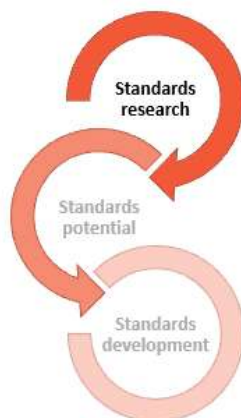
Identify standards relevant for the project
- Assessment of identified standardisation activities
- Provide insights from standards, standardisation work

Develop standardisation strategy
- Conduct standardisation potential workshops with the partners
- Comparison of identified standards with new potential topics
- Liaison with relevant standardisation committees

Performing standardisation activities
- Initiation of new standards / specifications (e.g. CEN Workshop Agreement - CWA)
- Contribution to ongoing standards development or update existing standards
- Dissemination of developed standards

M12

M24

M36

What are the next steps?

Identify standards relevant for the project
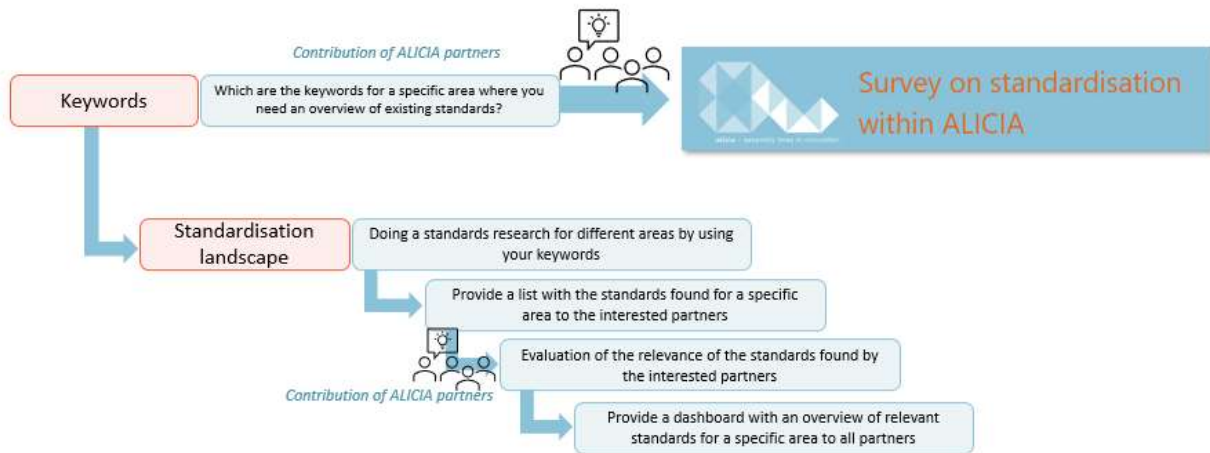
Questions?

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Group Research and Transfer

Annex 2: Survey partner's expertise on standardization

Have you ever been or are you currently active in a standardization committee or other organizations? AND If yes, in which one(s)?
Three persons from three different organizations have ever been active or are currently active in standardization, namely in the following standardization organizations: IEEE SMC (IEEE 7010), ISO/TC 299 Robotics, AAL Spain (Ambient Assisted Living Spain)

Have you ever developed a pre-standardization document such as a CWA (CEN Workshop Agreement)? AND If yes, please name the document/workshop.
One person has ever developed a pre-standardization document such as a CWA.

In which area do you apply or plan to apply standards as parts of your activities within ALICIA?
Nine of the participating persons apply or plan to apply standards as part of their activities within ALICIA, and the following Figure 13 gives an overview in which areas

Figure 13: Overview of areas in which the partners already use or plan to use standards for their work within ALICIA

Which standards do you already know / use within your activities in ALICIA?
The following standards are already known and/or used by the partners within ALICIA:
- ISO 14040 etc.
- VDI 2860
- ISO 9001:2015
- standards related to manufacturing systems design and safety of machines (e.g. EN ISO 10218-1-2, EN ISO 12100:2010 and other relevant standards)
- OPC-UA, MQTT, MT-Connect
- Catena-X, Gaia-X and Manufacturing-X Standards
- Some national DIN standards for data exchange

Is there something you would like to standardize within ALICIA? Or do you already know an area within ALICIA where standards are still missing?
- a sort of roadmap for circular manufacturing or circularity in automation or something similar
- Standardization of machine connectivity
- Sustainability, circular manufacturing, and digitalization of systems; manufacturing systems architectures, sustainable business models, digitalization of production systems
- Manufacturing systems architectures, sustainable business models, digitalization of production systems
- The data exchange between the different machines and modules
- The software requirements related to the ALICIA Tool
- Ontologies for assembly resources, resource description for Plug & Produce Middleware
- digital twin, request for quotation, equipment health assessment
- Data flow, AI component, and digital marketplace platform
- Defining new or integrating pre-existing adequate standards throughout the purchase and sale of used machinery so that the existing trust and acceptance barriers for the sector are lowered
- Standard for equipment re-use

Annex 3: Table of data of the ALICIA dashboard

List of relevant Standards for ALICIA, results outlined in red belong to the area "others", results outlined in dark green belong to the area "industry", results outlined in violet belong to the area "automation", results outlined in orange belong to the area "digitalization", results outlined in yellow belong to the area "quality management", results outlined in bright green belong to the area "circular economy"

document number	titel	publication date
ISO/IEC TR 24027	Information technology - Artificial intelligence (AI) - Bias in AI systems and AI aided decision making	2021-11-00
ISO/IEC TR 24368	Information technology - Artificial intelligence - Overview of ethical and societal concerns	2022-08-00
ISO/IEC 38507	Information technology - Governance of IT - Governance implications of the use of artificial intelligence by organizations	2022-04-00
VDI-EE 4030	Consideration of human reliability in the design of autonomous systems	2022-04-00
VDA Band 4 Abschnitt 3	Quality Management in the Automotive Industry - Quality Assurance in the Process Landscape - Section 3: Methods - Design for Manufacturing and Assembly (DFMA), Digital Mock-Up (DMU), Design of Experiments (DoE) – Trial Methodology, Manufacturing Feasibility Analysis, POKA YOKE, Quality Function Deployment (QFD), TRIZ, Economical Process Design and Process Control, 8D Method, 5 Why Method, Selection of Preventive Quality Management Methods	2020-08-00
ASAM ACI	Automatic Calibration Interface; Version 1.4.0	2014-06-30
ASAM GDI	Generic Device Interface; Version 4.5.0	2011-01-31
ASAM MDF	Measurement Data File Format; Version 4.2.0	2019-09-30
ITU-T Y.4500.11	oneM2M - Common terminology	2018-03-00
IECQ 03-3-2*CEIQ 03-3-2	IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE System) - Rules of procedure - Part 3-2: IECQ approved component products, related materials & assemblies scheme - IECQ approved component - automotive qualification programme (IECQ AC-AQP); Edition 3.0	2019-07-00
EN 100114-6	Rule of procedure 14: Quality assessment procedures - Part 6: Technology approval of electronic component manufacturers	1996-12-00
EN 100114-6/A1	CECC Quality assessment procedure for electronic components - Part 6: Technology approval of manufacturers; Amendment A1	1999-02-00
EN 1005-2+A1	Safety of machinery - Human physical performance - Part 2: Manual handling of machinery and component parts of machinery	2008-10-00
EN 1005-3+A1	Safety of machinery - Human physical performance - Part 3: Recommended force limits for machinery operation	2008-10-00
ISO/DIS 10218-1	Robotics - Safety requirements - Part 1: Industrial robots	2021-06-00
ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction	2010-11-00
EN 12102-1	Air conditioners, liquid chilling packages, heat pumps, process chillers and dehumidifiers with electrically driven compressors - Determination of the sound power level - Part 1: Air conditioners, liquid chilling packages, heat pumps for space heating and cooling, dehumidifiers and process chillers	2022-07-00
EN 12102-2	Air conditioners, liquid chilling packages, heat pumps, process chillers and dehumidifiers with electrically driven compressors - Determination of the sound power level - Part 2: Heat pump water heaters	2019-05-00
ISO 12620-2	Management of terminology resources - Data categories - Part 2: Repositories	2022-07-00
EN 12882	Conveyor belts for general purpose use - Electrical and flammability safety requirements	2015-08-00
ISO 13374-1	Condition monitoring and diagnostics of machines - Data processing, communication and presentation - Part 1: General guidelines	2003-03-00
EN 13675+A1	Safety of machinery - Safety requirements for tube forming and rolling mills and their finishing line equipment	2010-04-00
ISO 14123-2	Safety of machinery - Reduction of risks to health resulting from hazardous substances emitted by machinery - Part 2: Methodology leading to verification procedures	2015-11-00
ISO 14649-11	Industrial automation systems and integration - Physical device control - Data model for computerized numerical controllers - Part 11: Process data for milling	2004-12-00
ISO 14649-12	Industrial automation systems and integration - Physical device control - Data model for computerized numerical controllers - Part 12: Process data for turning	2005-12-00
ISO 14649-13	Automation systems and integration - Physical device control - Data model for computerized numerical controllers - Part 13: Process data for wire electrical discharge machining (wire-EDM)	2013-03-00
ISO 14649-14	Automation systems and integration - Physical device control - Data model for computerized numerical controllers - Part 14: Process data for sink electrical discharge machining (sink-EDM)	2013-03-00
EN 14656+A1	Safety of machinery - Safety requirements for extrusion presses for steel and non-ferrous metals	2010-04-00
EN 14677	Safety of machinery - Secondary steelmaking - Machinery and equipment for treatment of liquid steel	2008-04-00
EN 14681+A1	Safety of machinery - Safety requirements for machinery and equipment for production of steel by electric arc furnaces	2010-04-00
EN 14753	Safety of machinery - Safety requirements for machinery and equipment for continuous casting of steel	2022-03-00
EN 1550+A1	Machine-tools safety - Safety requirements for the design and construction of work holding chucks	2008-07-00
ISO 15519-1	Specification for diagrams for process industry - Part 1: General rules	2010-03-00
EN 15949	Safety of machinery - Safety requirements for bar mills, structural steel mills and wire rod mills	2012-02-00
ISO 16100-3	Industrial automation systems and integration - Manufacturing software capability profiling for interoperability - Part 3: Interface services, protocols and capability templates	2005-12-00
ISO 16100-5	Industrial automation systems and integration - Manufacturing software capability profiling for interoperability - Part 5: Methodology for profile matching using multiple capability class structures	2009-03-00
ISO 16156	Machine-tools safety - Safety requirements for the design and construction of work holding chucks	2004-02-00
ISO 16300-4	Automation systems and integration - Interoperability of capability units for manufacturing application solutions - Part 4: Capability unit assessment for the manufacturing application requirements	2019-12-00
DIN SPEC 16589	Information technology - Automatic identification and data capture techniques - Traceability Pointer to Process	2018-07-00
DIN SPEC 16592	Combining OPC Unified Architecture and Automation Markup Language	2016-12-00
EN 16774	Safety of machinery - Safety requirements for steel converter and associated equipment	2016-04-00
DIN EN 17071	Information technology - Automatic identification and data capture techniques - Electronic identification plate; German version EN 17071:2019	2019-05-00
EN 17161	Design for All - Accessibility following a Design for All approach in products, goods and services - Extending the range of users	2019-03-00
ISO 17916	Safety of thermal cutting machines	2016-03-00

ISO 18435-1	Industrial automation systems and integration - Diagnostics, capability assessment and maintenance applications integration - Part 1: Overview and general requirements	2009-08-00
ISO 18435-2	Industrial automation systems and integration - Diagnostics, capability assessment and maintenance applications integration - Part 2: Descriptions and definitions of application domain matrix elements	2012-09-00
ISO 18436-4	Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel - Part 4: Field lubricant analysis	2014-02-00
ISO 18436-7	Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel - Part 7: Thermography	2014-04-00
ETSI GS SMT 001 V 2.1.1	Surface Mount Technology (SMT) - Requirements for Embedded Communication Modules For Machine To Machine Communications	2015-06-00
ISO/TR 20218-1	Robotics - Safety design for industrial robot systems - Part 1: End-effectors	2018-08-00
ISO/TR 20218-2	Robotics - Safety design for industrial robot systems - Part 2: Manual load/unload stations	2017-12-00
ISO 20242-4	Industrial automation systems and integration - Service interface for testing applications - Part 4: Device capability profile template	2011-12-00
VDI 2048 Blatt 2	Control and quality improvement of process data and their uncertainties by means of correction calculation for operation and acceptance tests - Examples, especially retrofit measures	2018-06-00
ISO/TR 20527	Intelligent transport systems - Interoperability between interoperable fare management (IFM) systems and near field communication (NFC) mobile devices	2022-01-00
ISO/IEC/IEEE 21841	Systems and software engineering - Taxonomy of systems of systems	2019-07-00
VDI/VDE 2192	Interoperability in Industrie 4.0 systems - Quality of services - Characteristic parameters and influencing quantities	2021-10-00
ISO 22093	Industrial automation systems and integration - Physical device control - Dimensional Measuring Interface Standard (DMIS)	2011-05-00
CEN ISO/TR 22100-1	Safety of machinery - Relationship with ISO 12100 - Part 1: How ISO 12100 relates to type-B and type-C standards (ISO/TR 22100-1:2021)	2021-02-00
ISO 22385	Security and resilience - Authenticity, integrity and trust for products and documents - Guidelines to establish a framework for trust and interoperability	2023-02-00
ISO 23062	Foundry machinery - Safety requirements for molding and coremaking machinery and associated equipment	2022-07-00
ISO 23081-2	Information and documentation - Metadata for managing records - Part 2: Conceptual and implementation issues	2021-08-00
ISO/TR 23087	Automation systems and integration - The Big Picture of standards	2018-03-00
ISO 23952	Automation systems and integration - Quality information framework (QIF) - An integrated model for manufacturing quality information	2020-07-00
ISO/IEC FDIS 24392	Cybersecurity - Security reference model for industrial internet platform (SRM- IIP)	2023-04-00
ISO/TR 24463	Digital validation by effective use of simulation	2021-10-00
VDMA 24494	DISPO 015 - Bus interface between the high pressure metal die casting machine and extracting device	2012-03-00
VDMA 24495	DISPO 025 - Bus interface between the high pressure metal die casting machine and die spraying device	2012-03-00
ISO 26303	Machine tools - Short-term capability evaluation of machining processes on metal-cutting machine tools	2022-03-00
VDI/VDE 2645 Blatt 3	Capability test for bolting technology machines - Process capability test (PFU)	2019-02-00
VDI 2870 Blatt 1	Lean production systems - Basic principles, introduction, and review	2012-07-00
VDI 2885	Standardized data for maintenance planning and determination of maintenance costs - Data and data determination	2020-01-00
VDI 2889	Maintenance 4.0 - Diagnostic processes and methods	2022-04-00
ISO/TS 29002-10	Industrial automation systems and integration - Exchange of characteristic data - Part 10: Characteristic data exchange format	2009-12-00
ISO/TS 29002-31	Industrial automation systems and integration - Exchange of characteristic data - Part 31: Query for characteristic data	2009-12-00
ISO/TS 29002-4	Industrial automation systems and integration - Exchange of characteristic data - Part 4: Basic entities and types	2009-12-00
ISO/TS 29002-6	Industrial automation systems and integration - Exchange of characteristic data - Part 6: Concept dictionary terminology reference model	2010-04-00
VDI 3405 Blatt 6.2	Additive manufacturing processes - User safety on operating the manufacturing facilities - Laser sintering of polymers	2021-04-00
VDI/VDE 3850 Blatt 3	Development of usable user interfaces for technical plants - Features, design and applications of user interfaces with touchscreen	2015-11-00
VDI/VDE 3850 Blatt 2	Development of usable user interfaces for technical plants - Interaction devices for screens	2017-01-00
VDMA 40001-2	OPC UA for Machinery - Part 2: Process Values	2023-05-00
VDMA 40079	OPC UA interfaces for plastics and rubber machinery – Data exchange between injection moulding machines and robots	2022-01-00
VDMA 40100-2	OPC UA for Machine Vision - Part 2: Asset Management and Condition Monitoring	2022-11-00
VDMA 40210	OPC UA for Geometric Measurement Systems	2022-04-00
VDMA 40451-1	OPC UA for Tightening Systems - Part 1: Asset Management, Results and Basic Events	2022-01-00
VDMA 40501-1	OPC UA for Machine Tools - Part 1: Machine Monitoring and Job Overview	2022-09-00
VDMA 40502	OPC UA for Computerized Numerical Control (CNC) Systems	2019-11-00
VDMA 40540	OPC UA for Additive Manufacturing	2023-05-00
VDI 4499 Blatt 4	Digital factory - Ergonomic representation of humans in the digital factory	2015-03-00
DIN EN 60204-33*VDE 0113-33	Safety of machinery - Electrical equipment of machines - Part 33: Requirements for semiconductor fabrication equipment (IEC 60204-33:2009, modified); German version EN 60204-33:2011	2011-11-00
EN IEC 60812	Failure modes and effects analysis (FMEA and FMECA) (IEC 60812:2018)	2018-10-00
EN 61069-1	Industrial-process measurement, control and automation - Evaluation of system properties for the purpose of system assessment - Part 1: Terminology and basic concepts (IEC 61069-1:2016)	2016-10-00
EN 61069-3	Industrial-process measurement, control and automation - Evaluation of system properties for the purpose of system assessment - Part 3: Assessment of system functionality (IEC 61069-3:2016)	2016-10-00
EN 61069-4	Industrial-process measurement, control and automation - Evaluation of system properties for the purpose of system assessment - Part 4: Assessment of system performance (IEC 61069-4:2016)	2016-11-00
EN 61069-5	Industrial-process measurement, control and automation - Evaluation of system properties for the purpose of system assessment - Part 5: Assessment of system dependability (IEC 61069-5:2016)	2016-09-00
EN 61069-7	Industrial-process measurement, control and automation - Evaluation of system properties for the purpose of system assessment - Part 7: Assessment of system safety (IEC 61069-7:2016)	2016-09-00
EN 614-1+A1	Safety of machinery - Ergonomic design principles - Part 1: Terminology and general principles	2009-02-00
IEC 62541-5*CEI 62541-5	OPC unified architecture - Part 5: Information Model	2020-07-00
IEC 62541-6*CEI 62541-6	OPC unified architecture - Part 6: Mappings	2020-07-00
IEC 62541-7*CEI 62541-7	OPC unified architecture - Part 7: Profiles	2020-06-00
IEC 62541-8*CEI 62541-8	OPC unified architecture - Part 8: Data access	2020-06-00

IEC 62541-9*CEI 62541-9	OPC unified architecture - Part 9: Alarms and Conditions	2020-06-00
IEC 62714-1*CEI 62714-1	Engineering data exchange format for use in industrial automation systems engineering - Automation markup language - Part 1: Architecture and general requirements	2018-04-00
DIN EN IEC 62714-2	Engineering data exchange format for use in industrial automation systems engineering - Automation markup language - Part 2: Semantics libraries (IEC 65E/699/CD:2020); Text in German and English	2020-11-00
ISO/IEC 30162	Internet of Things (IoT) - Compatibility requirements and model for devices within industrial IoT systems	2022-02-00
EN 45554	General methods for the assessment of the ability to repair, reuse and upgrade energy-related products	2020-02-00
IEC 62541-11*CEI 62541-11	OPC unified architecture - Part 11: Historical Access	2020-06-00
IEC 62541-12*CEI 62541-12	OPC unified architecture - Part 12: Discovery and global services	2020-06-00
IEC 62541-13*CEI 62541-13	OPC Unified Architecture - Part 13: Aggregates	2020-06-00
IEC 62541-14*CEI 62541-14	OPC unified architecture - Part 14: PubSub	2020-07-00
IEC 62541-3*CEI 62541-3	OPC unified architecture - Part 3: Address Space Model	2020-07-00
IEC/PAS 63088*CEI/PAS 63088	Smart manufacturing - Reference architecture model industry 4.0 (RAMI4.0)	2017-03-00
prEN IEC 63278-1	Asset Administration Shell for industrial applications - Part 1: Asset Administration Shell structure	2022-05-00
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EN 17615	Plastics - Environmental Aspects - Vocabulary	2022-06-00
CWA 17807	Dismantling methods and protocols in a Circular Economy Framework - Composite recovery in the automotive industry	2021-10-00
ISO 20140-1	Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles	2019-09-00
ETSI ES 203199 V 1.3.1	Environmental Engineering (EE) - Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services	2015-02-00
VDI 2343 Blatt 7	Recycling of electrical and electronical equipment - Re-use	2014-12-00
ISO 26000	Guidance on social responsibility	2010-11-00
DIN/TS 35807	Guideline for Life Cycle Assessment according to DIN EN ISO 14001:2015-11	2020-08-00
ECMA-370	TED - The ECO Declaration	2019-06-00
VDI 4431	Life-cycle management in the manufacturing industry	2001-07-00
EN 45554	General methods for the assessment of the ability to repair, reuse and upgrade energy-related products	2020-02-00
VDI 4605	Evaluation of sustainability	2017-10-00
EN 50614	Requirements for the preparing for re-use of waste electrical and electronic equipment	2020-02-00
EN 50678	General procedure for verifying the effectiveness of the protective measures of electrical equipment after repair	2020-03-00
EN 50693	Product category rules for life cycle assessments of electronic and electrical products and systems	2019-08-00
ISO/DIS 59004	Circular Economy - Terminology, Principles and Guidance for Implementation	2023-04-00
ISO/DIS 59010	Circular Economy — Guidance on the transition of business models and value networks	2023-04-00
ISO/DIS 59020	Circular economy - Measuring and assessing circularity	2023-04-00
IEC 62309*CEI 62309	Dependability of products containing reused parts - Requirements for functionality and tests	2004-07-00
IEC 62619*CEI 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications	2022-05-00
IEC/TR 62921*CEI/TR 62921	Quantification methodology for greenhouse gas emissions for computers and monitors	2016-10-00
prEN IEC 63366	Product category rules for life cycle assessment of electrical and electronic products and systems.	2023-03-00
IEC 111/691/CDV*CEI 111/691/CDV*IEC 63366*CEI 63366	Product category rules for life cycle assessment of electrical and electronic products and systems.	2023-03-00
VDA 900-100	Guidance for Conducting Life Cycle Assessment Studies of Passenger Cars	2022-08-00
DIN SPEC 91472	Remanufacturing (Reman) - Quality classification for circular processes	2023-06-00

Annex 4: Stage Codes[43]

Stage	Substage						
				90 Decision			
	00 *Registration*	*20* *Start of main action*	*60* *Completion of main action*	*92* *Repeat an earlier phase*	*93* *Repeat current phase*	*98* *Abandon*	*99* *Proceed*
00 **Preliminary stage**	00.00 Proposal for new project received	00.20 Proposal for new project under review	00.60 Close of review			00.98 Proposal for new project abandoned	00.99 Approval to ballot proposal for new project
10 **Proposal stage**	10.00 Proposal for new project registered	10.20 New project ballot initiated	10.60 Close of voting	10.92 Proposal returned to submitter for further definition		10.98 New project rejected	10.99 Approval to new project approved
20 **Preparatory stage**	20.00 New project registered in TC/SC work programme	20.20 Working draft (WD) study initiated	20.60 Close of comment period			20.98 Project deleted	20.99 WD approved for registration as CD
30 Committee stage	30.00 Committee draft (CD) registered	30.20 CD Study initiated	30.60 Close of comment period	30.92 CD referred back to Working Group		30.98 Project deleted	30.99 CD approved for registration as DIS
40 **Enquiry stage**	40.00 DIS registered	40.20 DIS ballot initiated: 12 weeks	40.60 Close of voting	40.92 Full report circulated: DIS referred back to TC or SC	40.93 Full report circulated: decision for new DIS ballot	40.98 Project deleted	40.99 Full report circulated: DIS approved for registration as FDIS
50 **Approval stage**	50.00 Final text received or FDIS registered for formal approval	50.20 Proof sent to secretariat or FDIS ballot initiated: 8 weeks	50.60 Close of voting. Proof returned by secretariat	50.92 FDIS or proof referred back to TC or SC		50.98 Project deleted	50.99 FDIS or proof approved for publication

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43 https://www.iso.org/files/live/sites/isoorg/files/developing_standards/docs/en/stage_codes.pdf, last access: 16.10.2023

Stage	Substage						
				90 Decision			
	00 Registration	20 Start of main action	60 Completion of main action	92 Repeat an earlier phase	93 Repeat current phase	98 Abandon	99 Proceed
60 Publication stage	60.00 International Standard under publication		60.60 International Standard published				
90 Review stage		90.20 International Standard under periodical review	90.60 Close of review	90.92 International Standard to be revised	90.93 International Standard confirmed		90.99 Withdrawal of International Standard proposed by TC or SC
95 Withdrawal stage		95.20 Withdrawal ballot initiated	95.60 Close of voting	95.92 Decision not to withdraw International Standard			95.99 Withdrawal of International Standard