



BEEYONDERS

BEEYONDERS Contribution to Standardization – Initial version

D8.7: BEEYONDERS Contribution to Standardization / WP 8, T 8.6

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Technical references

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1 Introduction

1.1 Objectives

The purpose of this document is to present the work done and the results achieved in Task 8.6 all along the project. This task will facilitate and harmonize the active roles of BEEYONDERS consortium members within the main standardization bodies for the different technologies used or developed in the technical work packages. Three main activities will be achieved: first, we will identify European and International standards of interest for the project and integrate (through relevant partners) the corresponding standardization organizations. The second activity will be to get recommendations on the different standards that should be used in the project. And finally, BEEYONDERS will aim at sharing concrete contributions from the project results during standardization bodies meeting, to get recommendations and to see if new outcomes could be integrated to some standards.

This first version of D8.7 covers the work done during the first 16 months of the project, on the initial approach of the project's relation to standardization. This version contains all the parts and templates of the final document, but only the relevant parts have been filled in with the outcomes of the first work period: identification of the standards and committees interesting for the project. It will be completed all along the project with all standardization actions, to finally be released at the end of the project (M42) in its final version.

Chapter 1 of the document gives an introduction about contribution to standardization and methodology followed in task T8.6. Chapter 2, 3 and 4 present the different phases of project contribution to standardization: identification of standards, implementation of standards and contribution to standards. Chapter 5 suggests a REX and some recommendations about standardization during European projects, and finally chapter 6 concludes and presents some possible next steps.

1.2 Introduction to cooperation with standardization bodies

Figure 1 shows the most common interactions between a research project and the standardization world:

- Phase 1: During the specification phase of the research project, each requirement or use case identified shall be mapped with an existing standard solution. Project partners will consult standards and attend some standardization committees' meetings, looking for information.
- Phase 2: During the conception phase of the research project, each identified standard solution will be analyzed, and challenged with the objective of the project. Project partners will need more technical support from the standardization committees in order to ensure that the standard solution meets the project needs and is adequately used.
- Phase 3: During the development phase of the research project, each selected standard solution will be implemented and tested. When limitations or problems are identified, project teams will adapt by suggesting corrections or additions. When it is possible, project partners will demonstrate their on-going implementation of the standards to the corresponding committees.



- Phase 4: Finally, during the dissemination phase of the research project, the most interesting project outcomes will be pushed toward standardization committees. Depending on the outcome type, these “contribution to standardization” can be:
 - Demonstrating the standard implementation in the project through different use-cases.
 - Suggesting some correction / addition to the standard.
 - Suggestion a new (or a new version of a) standard.

Of course, modern research projects don’t always follow this kind of “linear” development process. But the presented organization can easily be adapted to “agile” methods, where several “iterations” are performed.

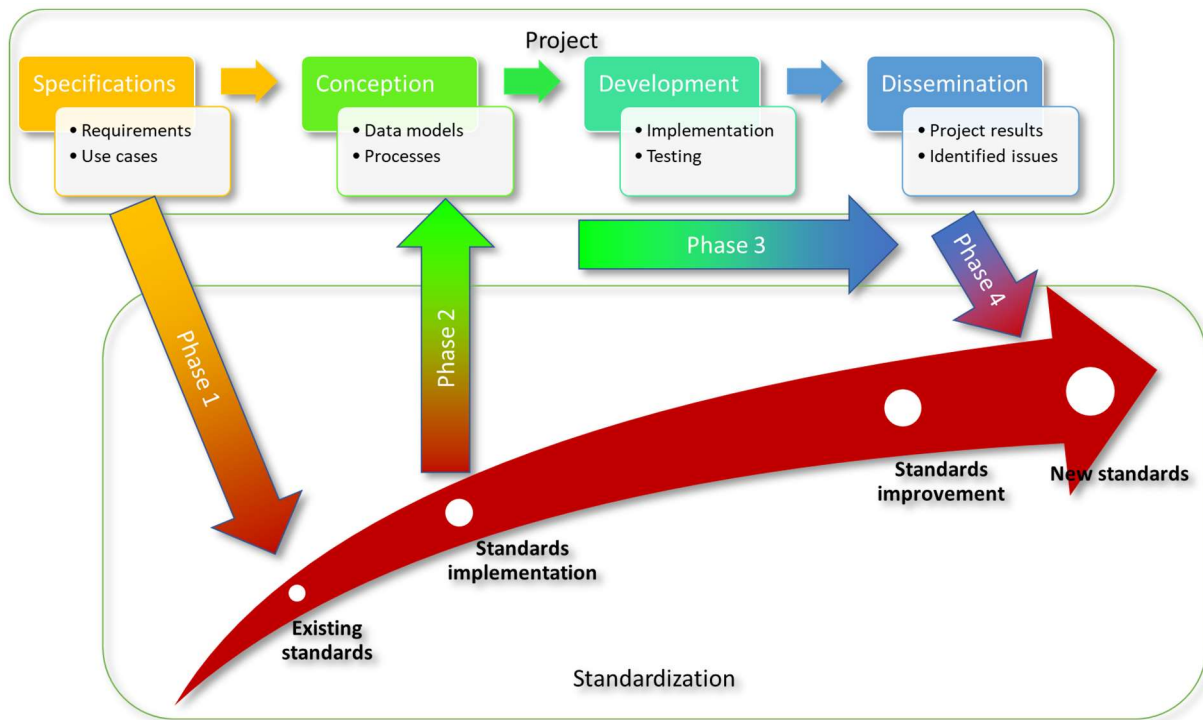


Figure 1 - Link between project and standards

1.3 Methodology and organization

The methodology followed in task T8.6 is based on several events:

- Standardization workshops organized all along the project, first with the project partners, but also, later in the project with external persons or organisations.
- Specific meetings on some standards of interest, when needed and requested by some technical partners.
- Meeting and Workshops with sister projects, in relation with task T8.5 (Liaison activities).

Task T8.6 works in close relation with other tasks and work packages:

- Other WP8 tasks, mainly
 - Task T8.2 (Dissemination and Communication Strategies)



- Task T8.4 (Exploitation strategy and business modelling)
- Task T8.5 (Liaison Activities)
- Technical work packages, mainly
 - WP3 for Digital Twin global software architecture aspects
 - WP4 for Autonomous vehicles & collaborative robotics
 - WP5 for Worker-centric technologies
 - WP6 for additive manufacturing
- WP7 for the specific disruptive technologies developed in each use case

2 Phase 1 – Identifying existing standards

The main objective of this first phase is to Identify the “standardization needs” of the project. By analyzing the requirements and the use cases, partners identify their needs, and try to map them with existing technologies and standards. This work is being done simultaneously in different Work packages, on the different technical subjects addressed by the project.

In the following parts, we have detailed, for each subject already identified, the existing standards we think are of interest for the project.

2.1 Identified standards

For each identified standard, a template table has been filled in, and will be updated along the project, in particular the following fields:

- Use for the project: How this standard can be used in the scope of BEEYONDERS project?
- Limitations: Have we identified some limitations for our use?
- Potential improvements: Which improvements / modifications could we provide?

2.1.1 Autonomous vehicles

2.1.1.1 *Wheel loaders*

Conventional wheel loaders are concerned by the following harmonized standards:

- EN 474-1:2022: Earthmoving Machinery - Safety - Part 1: General Requirements.
- EN 474-3:2022: Earthmoving Machinery - Safety - Part 3: Requirements for Loaders.

They define standardization of nomenclature, used classifications, ratings, technical requirements, and test methods, but also safety requirements, operation, maintenance manual format for earth-moving and related machinery.

These standards are managed by relevant Technical Committees:

- CEN / TC-151



- ISO / TC-127

A different standard has been published for autonomous and semi-autonomous vehicles in the scope of these committees: ISO 17757.

Some partners of the project would be interested in participating in these committees, but don't have corresponding national working groups. An interesting idea would be to initiate participation in these committees as a project, through partners already involved.

Additionally, a European directive has been identified and will be studied:

- Directive 2006/42/EC on machinery

This directive enables machinery that meets European Union (EU) health and safety requirements to be moved freely throughout the EU. This means that workers and the public are well protected when they use, or they are in contact with machinery. It only applies to products when they are first placed on the EU market. It helps the EU to be more innovative, efficient, and competitive.

The European Parliament Legislative Observatory Launched in 2021 an Ordinary legislative procedure (COD) about Regulation on machinery products. The purpose of this procedure (COD 2021/0105) is to improve and adapt the existing Machinery Directive to the new needs of the market and risks origination from emerging technologies.

So far, no specific standards for autonomous wheel loaders have been identified, but this has to be checked on a regular basis.

Table 1 - EN 474-1 description

Standard name	EN 474-1:2022
Full name	EN 474-1:2022: Earthmoving Machinery - Safety - Part 1: General Requirements
Version	30 March 2022
Status	Published
Documentation	https://standards.iteh.ai/catalog/standards/cen/84021cbc-6757-4970-856a-4ea8e5a34871/en-474-1-2022
Ontology	<i>NOT APPLICABLE</i>
Formats	<i>NOT APPLICABLE</i>
Description	The standard specifies the general safety requirements for earth-moving machinery, hereinafter also referred to as machines, described in EN ISO 6165:2012, except horizontal directional drills. This document gives the common safety requirements for earth-moving machinery families. This document specifies the appropriate technical measures to reduce risks arising from the significant hazards, hazardous situations and events during the whole foreseeable lifecycle of the machinery.
Maturity	EN 474-1 is a mature standard that has undergone multiple revisions and updates to address safety concerns related to earth-moving machinery. The standard has been widely adopted and implemented in the European Union and other regions where it is recognized.



Competitors	In North America, the ANSI/SAE J1116 standard and ISO 20474 series cover similar safety aspects for earth-moving machinery
Use for the project	[To be defined]
Limitations	While EN 474-1 is a comprehensive standard that addresses general safety requirements for earth-moving machinery, it may not cover all possible specific safety considerations that could arise in various contexts. Different applications and industries might have unique safety needs that are not fully addressed in this standard.
Potential improvements	[To be defined]
Committees	CEN/TC 151 - Construction equipment and building material machines - Safety

Table 2 - EN 474-3 description

Standard name	EN 474-3:2022
Full name	EN 474-3:2022: Earthmoving Machinery - Safety - Part 3: Requirements for Loaders
Version	30 March 2022
Status	Published
Documentation	https://standards.iteh.ai/catalog/standards/cen/86b89849-150f-4352-9a6c-f3ac4bf82181/en-474-3-2022
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	This document together with EN 474 1:2022 deals with all significant hazards, hazardous situations and events relevant to loaders when used as intended and under the conditions of misuse which are reasonably foreseeable by the manufacturer associated with the whole lifetime of the machine. The requirements of this document are complementary to the common requirements formulated in EN 474 1:2022. This document does not repeat the requirements of EN 474 1:2022 but supplements or modifies the requirements for loaders. This part also deals with fork applications, log handling applications, single heavy object handling applications and lifting operation applications.
Maturity	EN 474-3 is a mature standard that has undergone revisions and updates to address safety concerns specific to wheel loaders . The standard has been widely adopted in the European Union and other regions where it is recognized as a reference for ensuring the safety of hydraulic excavators.
Competitors	In North America, the ANSI/SAE J1116 standard and ISO 20474 series also cover safety aspects for various types of earth-moving machinery, including wheel loaders.
Use for the project	[To be defined]
Limitations	While EN 474-3 provides comprehensive safety requirements for hydraulic excavators, it may not cover all specific safety considerations that could arise in various contexts or with rapidly



	evolving technologies. Different applications and industries might have unique safety needs that are not fully addressed in this standard.
Potential improvements	• [To be defined]
Committees	CEN/TC 151 - Construction equipment and building material machines - Safety

Table 3 – ISO 17757:2019 description

Standard name	ISO 17757:2019
Full name	ISO 17757:2019: Earthmoving Machinery and Mining - Autonomous and semi-autonomous machine system safety
Version	2019-07
Status	Published
Documentation	https://www.iso.org/standard/76126.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	This document provides safety requirements for autonomous and semi-autonomous machines (ASAM) used in earth-moving and mining operations, and their autonomous or semi-autonomous machine system (ASAMS). It specifies safety criteria both for the machines and their associated system and infrastructure, including hardware and software, and provides guidance on safe use in their functional environments during the machine and system life cycle. It also defines terms and definitions related to ASAMS. It is applicable to autonomous and semi-autonomous versions of the earth-moving machinery (EMM) defined in ISO 6165 and of mobile mining machines used in either surface or underground applications. Its principles and many of its provisions can be applied to other types of ASAM used on the worksites.
Maturity	ISO 17757:2019 is a mature standard that has undergone revisions and updates to address safety concerns specific to autonomous machines and semi-autonomous machines (ASAM). The standard has been widely adopted in the European Union and other regions where it is recognized as a reference for ensuring the safety of (ASAM).
Competitors	• [Not known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	ISO/TC 127/SC 2 Safety, ergonomics and general requirements



2.1.1.2 *Inspection vehicles (Road maintenance Use Case)*

Inspection vehicles can be considered as machinery, and thus are submitted to previous standards and regulations of the previous chapter.

One specific standard has been identified for industrial drawlers trucks:

- ISO 3691-4:2020 - Industrial trucks — Safety requirements and verification — Part 4: Driverless industrial trucks and their systems

This standard specifically addresses the case of autonomous or driverless trucks, which are in the scope of our BEEYONDERS project.

Additional regulations and standards coming to the automotive sector may apply and will be investigated.

Table 4 - ISO 3691-4 description

Standard name	ISO 3691-4:2020
Full name	ISO 3691-4:2020 - Industrial trucks — Safety requirements and verification — Part 4: Driverless industrial trucks and their systems
Version	02-2020 corrected version 10-2020
Status	Published
Documentation	https://www.iso.org/standard/70660.html
Ontology	<i>NOT APPLICABLE</i>
Formats	<i>NOT APPLICABLE</i>
Description	This document specifies safety requirements and the means for their verification for driverless industrial trucks and their systems. Examples of driverless industrial trucks (trucks of ISO 5053-1) can also be known as: "automated guided vehicle", "autonomous mobile robot", "bots", "automated guided cart", "tunnel tugger", "under cart", etc. This document also contains requirements for driverless industrial trucks which are provided with: automatic modes which either require operators' action(s) to initiate or enable such automatic operations; the capability to transport one or more riders (which are neither considered as drivers nor as operators); additional manual modes which allow operators to operate the truck manually; or a maintenance mode which allows manual operation of truck functions for maintenance reasons.
Maturity	• [To be defined]
Competitors	• [Not Known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	• ISO/TC 110/SC 2 Safety of powered industrial trucks



2.1.1.3 *Agricultural machinery and tractors*

Agricultural machinery and tractors may be considered machinery and are therefore subject to the previous standards and regulations of the previous section.

One specific standard has been identified for highly automated agricultural machines:

- ISO 18497:2018 Agricultural machinery and tractors – Safety of highly automated agricultural machines – Principles for design

This standard specifically addresses the case of autonomous or driverless tractors and automated agricultural machinery, which are in the scope of our BEEYONDERS project.

Table 5 - ISO 18497:2018 description

Standard name	ISO 18497:2018
Full name	ISO 18497:2018 - Agricultural machinery and tractors – Safety of highly automated agricultural machines – Principles for design
Version	Publication date: 2018-11
Status	Published
Documentation	https://www.iso.org/standard/62659.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	This document specifies principles for the design of highly automated aspects of highly automated machines and vehicles (e.g., agricultural tractors, tractors, tractor implement systems, implements and self-propelled machinery) during agricultural field operations. In addition, it provides guidance on the type of information on safe working practices (including information about residual risks) to be provided by the manufacturer.
Maturity	Under development / Will be replaced by: ISO/FDIS 18497-1 ISO/FDIS 18497-2 ISO/FDIS 18497-3 ISO/FDIS 18497-4
Competitors	• [Not known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	• ISO/TC 23/SC 19 Agricultural electronics

2.1.2 Drones

Concerning flying drones, we have to make a difference between Indoor and Outdoor applications.



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement N° 101058548.

For indoor application, no specific regulation applies, as long as:

- You're aligned with safety and security procedures that apply in your country.
- The owner of the facility allows you to use drones.

On the other hand, for outdoor applications, you need to comply to specific European regulations, in terms of requirements for the pilots, emergency procedures, safety, ...

Some partners are actively working with national and European authorities to adapt the current regulation: definition of new use cases, in order to accommodate the balance between innovation and regulation.

CATEC is leading one of the subgroups of EUROCAE WG-105, which intent to define new Use cases related with innovative application of drones into construction industry. Use cases and technical development of BEEYONDERS project could be of very high interest for this working group, and CATEC could push these inputs to the committee.

At ISO level, "TC 20/SC 16 – Unmanned aircraft systems" is responsible for standardization in the field of unmanned aircraft systems (UAS) including, but not limited to, classification, design, manufacture, operation (including maintenance) and safety management of UAS operations. This committee publishes two main standards series concerning drones:

- ISO 21384 series – Unmanned aircraft systems (UAS)
- ISO 23629 series – UAS traffic management (UTM)

Table 6 - ISO 21384 description

Standard name	ISO 21384 series
Full name	ISO 21384 series – Unmanned aircraft systems (UAS)
Version	2021-12
Status	Published
Documentation	https://www.iso.org/standard/80123.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	This document specifies requirements for ensuring the quality and safety of the design and manufacture of unmanned aircraft systems (UAS) that include unmanned aircraft (UA), remote pilot stations (RPS), datalinks, payloads, and associated support equipment. This document includes information regarding the unmanned aircraft, any associated remote pilot station (RPS)(s), the command-and-control links (C2 Link), any other required data links (e.g., payload, traffic management information, vehicle identification) and any other system elements as can be required. The document is applicable to the reasonable expected use of a UAS. This document is applicable: to UAS designed for use where a State aviation authority has determined a Certificate of Airworthiness (C of A) is not required; where a C of A is required, to complement technical standards



	published by the aviation authority for the purposes of building the certification basis; or as an alternative means of compliance if acceptable to the aviation authority.
Maturity	• [To be defined]
Competitors	• [Not known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	ISO/TC 20/SC 16 Unmanned aircraft systems

Table 7 - ISO 23629-5 description

Standard name	ISO 23629-5:2023
Full name	ISO 23629-5:2023 UAS traffic management (UTM) — Part 5: UTM functional structure
Version	2023-04
Status	Published
Documentation	https://www.iso.org/standard/78961.html
Ontology	<i>NOT APPLICABLE</i>
Formats	<i>NOT APPLICABLE</i>
Description	This document is dedicated to establishing a common understanding of UTM core functions and functional structure. It provides a detailed description of the UTM system layer given in the UTM Framework. This document excludes: role-sharing among entities constituting UTM, which is left to implementations; technical methodology of communication or data transaction among core functions; business model of players engaging in a function of UTM.
Maturity	• [To be defined]
Competitors	• [Not known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	ISO/TC 20/SC 16 Unmanned aircraft systems

2.1.3 Smart wearables

In March 2017, the IEC set up Technical Committee 124 ([TC 124](#)) with the aim of providing standards in the field of wearable electronic devices and technologies which includes materials and devices that are patchable, implantable, ingestible as well as those made from electronic textile materials. Four working groups have been organized to cover standardization in areas such as terminology and the measurement and evaluation methods for e-textiles, all other materials as well as devices and systems.



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ISO/IEC Joint Technical Committee JTC 1/SC 35 work on standards related to User interfaces. In particular they have published in 2019 the standard: ISO/IEC 30071-1:2019 – Information technology — Development of user interface accessibility — Part 1: Code of practice for creating accessible ICT products and services.

Table 8 - ISO/IEC 30071-1 description

Standard name	ISO/IEC 30071-1
Full name	ISO/IEC 30071-1:2019 – Information technology — Development of user interface accessibility — Part 1: Code of practice for creating accessible ICT products and services
Version	2019-05
Status	Published
Documentation	https://www.iso.org/standard/70913.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	This document takes a holistic approach to the accessibility of information and communications technology (ICT) by combining guidance on implementing the accessibility of ICT systems (ICT accessibility) both at organizational and system development levels. This document gives guidelines for building and maintaining ICT systems that are accessible to diverse users. This document is applicable to all types of organizations. This document applies to the breadth of ICT systems and the results of convergent and emerging technologies within an organization including information systems; intranet systems; websites; mobile and wearable applications; social media; and Internet of Things (IoT) systems.
Maturity	[To be evaluated]
Competitors	• [Not known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	• ISO/IEC JTC 1/SC 35 User interfaces

On a more global aspect, all personal data acquired by smart wearables are submitted to GDPR (<https://gdpr-info.eu/>) European regulation.

2.1.4 Exoskeleton

In the scope of BEEYONDERS project, exoskeletons would be used only indoor (building Use case). Exoskeleton is considered as a machine, and thus is submitted to regulations relatives to safety of machinery:

- ISO/TC 199 – Safety of machinery
 - o ISO 12100:2010 – Safety of machinery — General principles for design — Risk assessment and risk reduction



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Exoskeleton existing standards related to the manufacturing:

- Related to emission: EN 61326 series.
- Related to electrical problem: EN 61010 series.

Exoskeleton existing standards related to the tasks:

- Carry heavy loads: Technical Committee: ISO/TC 159/SC 3 – Anthropometry and biomechanics:
 - ISO 11228-1:2021 Ergonomics — Manual handling — Part 1: Lifting, lowering and carrying.
 - ISO 11228-2:2007 Ergonomics — Manual handling — Part 2: Pushing and pulling.
 - ISO/AWI 11228-3 Ergonomics — Manual handling — Part 3: Handling of low loads at high frequency [Under development]

BEEYONDERS partner IIT is part of Italian ISO group WG: UNI:ISO CT042/SC01/GL16. This group is working on a state-of-the-art report, in order to regulate the benefits of exoskeletons. This report should be submitted by the end of this year or the beginning of next year.

Table 9 - ISO 12100 description

Standard name	ISO 12100:2010
Full name	ISO 12100:2010 Safety of machinery — General principles for design — Risk assessment and risk reduction
Version	2010-11
Status	Published
Documentation	https://www.iso.org/standard/51528.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	ISO 12100:2010 specifies basic terminology, principles and a methodology for achieving safety in the design of machinery. It specifies principles of risk assessment and risk reduction to help designers in achieving this objective. These principles are based on knowledge and experience of the design, use, incidents, accidents and risks associated with machinery. Procedures are described for identifying hazards and estimating and evaluating risks during relevant phases of the machine life cycle, and for the elimination of hazards or sufficient risk reduction. Guidance is given on the documentation and verification of the risk assessment and risk reduction process.
Maturity	[To be defined]
Competitors	• [Not Known]
Use for the project	• Certification of the exoskeleton to be compliant to safety requirements
Limitations	• n/a
Potential improvements	• n/a
Committees	• ISO/TC 199 Safety of machinery



Table 10 - EN 61326 description

Standard name	EN 61326 series
Full name	Related to emission:
Version	10/05/2013
Status	Published
Documentation	https://www.boutique.afnor.org/fr-fr/norme/nf-en-6132631/materiel-electrique-de-mesure-de-commande-et-de-laboratoire-exigences-relat/fa188208/79555#AreasStoreProductsSummaryView
Ontology	<i>NOT APPLICABLE</i>
Formats	<i>NOT APPLICABLE</i>
Description	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: immunity requirements for safety-related systems and for equipment intended to perform safety - related functions - General industrial applications Functional safety is that part of the overall safety relating to the equipment under control (EUC) and the EUC control system which depends on the correct functioning of the electrical safety-related systems. To achieve this, all items of equipment of the safety-related system which are involved in the performance of the safety functions must behave in a specified manner under all relevant conditions. The IEC basic safety publication for functional safety of electrical/electronic/programmable electronic safety-related systems is IEC 61508. It sets the overall requirements to achieve functional safety. Sufficient immunity to electromagnetic disturbances is one of those requirements.
Maturity	• [To be defined]
Competitors	• [Not known]
Use for the project	• Certification of the exoskeleton to be compliant to safety requirements
Limitations	• n/a
Potential improvements	• n/a
Committees	• [Not known]

Table 11 - EN 61010 description

Standard name	EN 61010 series
Full name	Related to electrical problem:
Version	Published
Status	https://www.boutique.afnor.org/fr-fr/norme/nf-en-610101/regles-de-securite-pour-appareils-electriques-de-mesurage-de-regulation-et/fa139700/1119#AreasStoreProductsSummaryView
Ontology	<i>NOT APPLICABLE</i>
Formats	<i>NOT APPLICABLE</i>



Description	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1 : general requirements This International Standard specifies the safety requirements that are generally applicable to all equipment within its scope. For certain types of equipment, these requirements will be supplemented or modified by the special requirements of one, or more than one, scope requirement (part 2 of the standard which must be read in conjunction with the part 1 requirements)
Maturity	• [Not known]
Competitors	• [To be defined]
Use for the project	• Certification of the exoskeleton to be compliant to safety requirements
Limitations	• n/a
Potential improvements	• n/a
Committees	• [Not known]

Table 12 - ISO 11228-1 description

Standard name	ISO 11228-1:2021
Full name	ISO 11228-1:2021 Ergonomics — Manual handling — Part 1: Lifting, lowering and carrying
Version	2021
Status	Published
Documentation	https://www.iso.org/standard/76820.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	This document specifies recommended limits for manual lifting, lowering and carrying while taking into account the intensity, the frequency and the duration of the task. It is designed to provide requirements and recommendations on the assessment of several task variables, allowing the health risks for the working population to be evaluated.
Maturity	[To be evaluated]
Competitors	• [Not known]
Use for the project	• Evaluation of the ergonomic risk associated with lifting, lowering and carrying tasks
Limitations	• The standard does not consider the effects introduced by an exoskeleton that assists the user while carrying out these tasks
Potential improvements	• Considering how to model an exoskeleton's effects and benefits when it generates assistance.
Committees	• [Not known]

Table 13 - ISO 11228-2 description

Standard name	ISO 11228-2:2007
Full name	ISO 11228-2:2007 Ergonomics — Manual handling — Part 2: Pushing and pulling



Version	2021-10
Status	Published
Documentation	https://www.iso.org/standard/26521.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	This document specifies recommended limits for manual lifting, lowering and carrying while taking into account the intensity, the frequency and the duration of the task. It is designed to provide requirements and recommendations on the assessment of several task variables, allowing the health risks for the working population to be evaluated. This document applies to manual handling of objects with a mass of 3 kg or more and to moderate walking speed, i.e., 0,5 m/s to 1,0 m/s on a horizontal level surface. This document is based on an 8 h working day, but also covers more prolonged working times, up to 12 h. It also addresses the analysis of combined lifting, lowering and carrying tasks in a shift during a day.
Maturity	[to be evaluated]
Competitors	• [Not known]
Use for the project	• Evaluation of the ergonomic risk associated with pushing and pulling tasks
Limitations	• The standard does not consider the effects introduced by an exoskeleton that assists the user while carrying out these tasks
Potential improvements	• Considering how to model an exoskeleton's effects and benefits when it generates assistance
Committees	• ISO/TC 159/SC 3 Anthropometry and biomechanics

Table 14 - ISO 11228-3 description

Standard name	ISO/AWI 11228-3
Full name	ISO/AWI 11228-3 Ergonomics — Manual handling — Part 3: Handling of low loads at high frequency
Version	2009-10 (corrected)
Status	Published
Documentation	https://www.iso.org/standard/26522.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	ISO 11228-3:2006 establishes ergonomic recommendations for repetitive work tasks involving the manual handling of low loads at high frequency. It provides guidance on the identification and assessment of risk factors commonly associated with handling low loads at high frequency, thereby allowing evaluation of the related health risks to the working population. The recommendations apply to the adult working population and are intended to give reasonable protection for nearly all healthy adults. Those recommendations concerning health risks and control measures are mainly based on experimental studies regarding musculoskeletal loading, discomfort/pain and endurance/fatigue related to methods of working. ISO



	11228-3:2006 is intended to provide information for all those involved in the design or redesign of work, jobs and products.
Maturity	• [Not known]
Competitors	• [Not known]
Use for the project	• Evaluation of the ergonomic risk associated with repetitive movement of low loads
Limitations	• The standard does not consider the effects introduced by an exoskeleton that assists the user while carrying out these tasks
Potential improvements	• Considering how to model an exoskeleton's effects and benefits when it generates assistance.
Committees	• ISO/TC 159/SC 3 Anthropometry and biomechanics

2.1.5 Biocompatibility mortars

So far, no existing standard related to biocompatibility mortar has been identified.

Deeper investigation will be performed to identify potential relation with other standardization aspects.

2.1.6 Additive manufacturing

ISO/TC 261 Additive manufacturing

Standardization in the field of Additive Manufacturing (AM) concerning their processes, terms and definitions, process chains (Hard- and Software), test procedures, quality parameters, supply agreements and all kind of fundamentals. In relation to ISO/TC 59 Buildings and civil engineering works.

BEEYONDERS partner **HOLCIM** Participated in the working group: It defines quality assurance requirements for Additive Construction (AC) concerning building and construction projects in which additive manufacturing techniques are used for construction. The requirements are independent of the material/materials and process category used.

ISO/ASTM DIS 52939 Additive Manufacturing for construction — Qualification principles — Structural and infrastructure elements [Under development]

Table 15 - ISO 21930 description

Standard name	ISO 21930
Full name	ISO 21930, Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services
Version	2017-07
Status	Published
Documentation	https://www.iso.org/standard/61694.html
Ontology	NOT APPLICABLE
Formats	NOT APPLICABLE
Description	ISO 21930:2017 provides the principles, specifications and requirements to develop an environmental product declaration (EPD) for construction



	products and services, construction elements and integrated technical systems used in any type of construction works. ISO 21930:2017 complements ISO 14025 by providing specific requirements for the EPD of construction products and services. ISO 21930:2017 establishes a core set of requirements to be considered as core product category rules (PCR) to develop an EPD for any construction product or service.
Maturity	• [To be defined]
Competitors	• [Not known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	ISO/TC 59/SC 17 Sustainability in buildings and civil engineering works

Table 16 - ISO 52950 description

Standard name	ISO/ASTM 52950
Full name	ISO/ASTM 52950, Additive manufacturing — General principles — Overview of data processing
Version	2021-01
Status	published
Documentation	https://www.iso.org/standard/76830.html
Ontology	<i>NOT APPLICABLE</i>
Formats	<i>NOT APPLICABLE</i>
Description	This document covers the principal considerations which apply to data exchange for additive manufacturing. It specifies terms and definitions which enable information to be exchanged describing geometries or parts such that they can be additively manufactured. The data exchange method outlines file type, data enclosed formatting of such data and what this can be used for. This document — enables a suitable format for data exchange to be specified, — describes the existing developments for additive manufacturing of 3D geometries, — outlines existing file formats used as part of the existing developments, — enables understanding of necessary features for data exchange, for adopters of this document. This document is aimed at users and producers of additive manufacturing processes and associated software systems.
Maturity	• [To be defined]
Competitors	• [Not known]
Use for the project	• [To be defined]
Limitations	• [To be defined]
Potential improvements	• [To be defined]
Committees	ISO/TC 261 Additive manufacturing



Related standards:

- ISO 21930, Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services
- ISO/ASTM 52950, Additive manufacturing — General principles — Overview of data processing

2.1.7 Digital Twin

This part of the document is based on the early analysis of D3.1 and D4.1 deliverables.

- D3.1 - Digital Twin Design and Architecture: this deliverable provides a detailed description of the requirements, user case analysis and architecture of the Digital Twin Platform design for BEEYONDERS project.
- D4.1 – Modelling and Data Link Interface: this deliverable defines the technical interfaces between the Autonomous vehicles & Collaborative robotics and the Digital Twin implemented in the BEEYONDERS project.

This first analysis of available DT standards will be improved during the technical developments of WP3 and WP4.

From a general point of view, there are quite few European and international standards related to Digital Twin. The most important ones are:

- ISO 23247 is an international standard titled "Digital Twin Framework for Manufacturing." It provides a framework for defining and representing digital twins in the manufacturing domain. The standard covers various aspects such as the definition, architecture, modelling, and interoperability of digital twins.
- ISO/IEC 30145: ISO/IEC 30145 is an international standard titled "Data Schema for Digital Twin." It focuses on the data schema aspects of digital twins, providing guidelines for structuring and organizing the data associated with digital twins. The standard defines a common data model and structure to facilitate interoperability and data exchange.
- IEC/ISO 62832: IEC/ISO 62832 is a joint standard developed by the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) titled "Energy Efficiency in Industry Systems." While not specifically focused on digital twins, it includes a section on "Digital Twins for Energy Efficiency" that provides guidance on using digital twins for energy optimization in industrial systems.

These standards contribute to the development and adoption of digital twin technologies by providing guidance, frameworks, and best practices. They address various domains such as manufacturing, energy, agriculture, and water, helping to establish common approaches and interoperability in the implementation and management of digital twins.

From our first analysis, we did not identify any Digital Twin standard specifically related to Architecture, Engineering, and Construction (AEC) sector. While focusing on the manufacturing domain "ISO 23247:2021 - Digital Twin Framework for Manufacturing" standard principles and concepts can be applied to other sectors such as AEC. ISO 23247 provides a framework for defining and representing digital twins, including those used in the AEC sector. The standard covers various aspects of digital twins, including their definition, architecture, modeling, and interoperability. It offers guidelines for creating and managing digital twins



throughout their lifecycle, from design and construction to operation and maintenance. It provides valuable insights and principles that can be adapted and implemented in the AEC sector's digital twin applications. The standard emphasizes the importance of data integration, data flow, and interoperability among various systems and stakeholders, which are key considerations in the AEC domain.

It is worth noting that while ISO 23247 is a widely recognized standard, the AEC industry is still evolving in terms of specific standards and best practices for digital twins. Organizations and industry bodies within the AEC sector are actively working on developing domain-specific guidelines and standards to address the unique challenges and requirements of digital twins in architecture, engineering, and construction.

Now, we'll try to investigate in more detail each part of the architecture components presented in D3.1 and D4.1. We ordered then following the structuration in D3.1

2.1.7.1 Data Source Layer

Several types of data can be used as inputs in the digital twin platform:

- As-designed models can be imported into the DT platform using one of the “Open-BIM” data formats:
 - IFC format (ISO 16739-1:2018) allows to import BIM model from any CAD software.
 - A new version of this format, including now information for Infrastructure projects (roads, bridges, rail, ports & waterways) is under voting process at ISO (ISO/DIS 16739-1).
 - CityGML and LandInfra/InfraGML can be used to import data about city or landscape surroundings.
 - Data management and governance process in BIM project are standardized in the ISO 19650 series.

Table 17 - IFC description

Standard name	IFC
Full name	Industry Foundation Classes
Version	4.0.2.1 (Version 4.0 - Addendum 2 - Technical Corrigendum 1)
Status	ISO 16739-1:2018
Documentation	https://standards.buildingsmart.org/IFC/RELEASE/IFC4/ADD2_TC1/HTML
Ontology	https://standards.buildingsmart.org/IFC/DEV/IFC4/ADD2/OWL/index.html
Formats	Express, XSD, RDF, TTL
Description	The Industry Foundation Classes, IFC, are an open international standard for Building Information Model (BIM) data that are exchanged and shared among software applications used by the various participants in the construction or facility management industry sector. The standard includes definitions that cover data required for buildings over their life cycle. This release, and upcoming releases, extend the scope to include data definitions for infrastructure assets over their life cycle as well.
Maturity	Widely used for building design and construction phases Starting to be used in building exploitation phase
Competitors	• Non standards: Revit file format
Use for the project	• Import CAD data into the digital twin



Limitations	• Can be very complex to use
Committees	• buildingSMART International, • CEN/TC 442, • ISO/TC 59/SC 13

Table 18 - CityGML description

Standard name	CityGML
Full name	OGC City Geography Markup Language
Version	Version 3.0
Status	Released
Documentation	https://docs.ogc.org/is/21-006r2/21-006r2.html
Data model	https://github.com/opengeospatial/CityGML-3.0CM/tree/master/Implementations
Formats	GML, Json, SQL
Description	The CityGML standard defines a conceptual model and exchange format for the representation, storage and exchange of virtual 3D city models. It facilitates the integration of urban geodata for a variety of applications for Smart Cities and Urban Digital Twins, including urban and landscape planning; Building Information Modeling (BIM); mobile telecommunication; disaster management; 3D cadaster; tourism; vehicle & pedestrian navigation; autonomous driving and driving assistance; facility management, and; energy, traffic and environmental simulations.
Maturity	CityGML has gained significant adoption in urban planning, geospatial industries, and 3D city modeling projects worldwide. Its adoption indicates a degree of maturity and acceptance within the relevant communities.
Competitors	• IndoorGML • Proprietary formats (CityEngine, InfraWorks, CityPlanner)
Use for the project	• Import City data models into the digital twin
Limitations	• CityGML can be quite complex, especially for users who are new to 3D geospatial data. Creating, manipulating, and interpreting CityGML data may require a certain level of expertise. • 3D city models in CityGML format can be data-intensive due to the level of detail and the inclusion of geometric and semantic information. Handling large datasets can be a challenge.
Committees	• Open Geospatial Consortium

- On-site data can be acquired and imported into the DT platform using several Cloud Points formats:



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement N° 101058548.

- ISO 19107 is an international standard that specifies a conceptual schema for describing spatial objects, including point cloud data. It provides a framework for representing geometric objects, their properties, and relationships. While ISO 19107 does not specifically focus on point clouds, it can be used as a foundation for modelling point cloud data.
- ISO 19115-1 is part of the ISO 19115 series of standards that define metadata for geographic information. It provides a standard for describing the metadata of datasets, including point cloud data. ISO 19115-1 covers information about the content, quality, and lineage of the data, among other aspects.
- LAS/LAZ Format: The LAS (Lidar Data Exchange Format) is a common file format for storing airborne lidar point cloud data. It was developed by the American Society for Photogrammetry and Remote Sensing (ASPRS) and is widely used in the industry. LAS files can be compressed using the LASzip compression method, resulting in the LAZ format.
- ASTM E57: ASTM E57 is a standard developed by ASTM International that defines a file format and data exchange protocol for 3D imaging systems, including point cloud data. It provides a standardized way of storing, managing, and exchanging point cloud data between different software applications and systems. ASTM E57 is fully specified in document “ASTM E2807-11(2019) Standard Specification for 3D Imaging Data Exchange, Version 1.0” (<https://www.astm.org/e2807-11r19.html>).
- INSPIRE (Infrastructure for Spatial Information in Europe) also includes specifications for handling point cloud data. The INSPIRE Point Cloud Data Specification provides guidelines for the storage, processing, and dissemination of point cloud data within the context of spatial data infrastructures in Europe.

These standards help ensure interoperability, data exchange, and proper documentation of point cloud data. They cover various aspects, including data representation, metadata, file formats, and data exchange protocols, facilitating the use and integration of point cloud data in different applications and domains.

Several technical partners of the project are very familiar with (and have already used) the Point Cloud Data (PCD) format. The PCD format comes from The Point Cloud Library (PCL) project, which is an open-source library of algorithms for point cloud processing tasks and 3D geometry processing, such as occur in three-dimensional computer vision. The PCD was created because existing formats did not support some of the features provided by the PCL library. This format is very easy to transform and very common in robotics applications. In the scope of BEEYONDERS project, it is considered to use PCD format for robotics application and real-time processing, and to transform data into a more standard format when imported into DT platform, for off-line computation and visualization.

- Time series data: There are several European and international standards that deal with time series data. Here are a few notable ones:
 - ISO 8601: ISO 8601 is an international standard that specifies formats for representing dates, times, and durations. It provides a standardized way of representing time series data and is widely used for data interchange and storage.
 - ISO 19156: ISO 19156, also known as the Observations and Measurements standard, provides a framework for modelling and encoding observations and measurements, including time series data. It defines a conceptual model and an XML encoding for representing time series observations.



- OGC Sensor Observation Service (SOS): The Sensor Observation Service is a standard developed by the Open Geospatial Consortium (OGC) for querying and accessing time series data from sensors. It provides a standardized interface for retrieving time series observations and metadata.
- W3C Semantic Sensor Network (SSN) Ontology: The W3C SSN Ontology is a specification that defines a set of concepts and relationships for representing sensor observations and time series data on the Semantic Web. It provides a semantic framework for describing and integrating time series data from different sources.
- INSPIRE Time Series Data Specification: INSPIRE (Infrastructure for Spatial Information in Europe) is a European directive that aims to establish a European Spatial Data Infrastructure. The INSPIRE Time Series Data Specification provides guidelines for the harmonized representation and exchange of time series data in the context of spatial data infrastructures.

These standards provide guidance and specifications for various aspects of handling time series data, including representation formats, data models, and data exchange protocols. They are widely recognized and used in various domains, including environmental monitoring, smart cities, and scientific research.

2.1.7.2 Acquisition layer

This layer refers to those software elements that allow the communication with the physical elements. This software will be responsible either for acquiring the information from the sensors or systems and for sending commands to them, providing a unified interface toward upper layers.

The communication between the different systems, devices, sensors, actuators and databases will be orchestrated by a middleware pushing different communication protocols. For this purpose, a browser-based flow editor called NodeRED has been identified. Node-RED is an open-source flow-based development tool for visual programming. It is designed to simplify the process of wiring together devices, APIs, and online services for IoT (Internet of Things) applications. Node-RED allows users to create flows, which are sequences of processing steps or actions, by connecting nodes visually on a web-based interface.

Node-RED itself is not a standard or based on any standards, but it is often used in conjunction with various standards and protocols in the fields of IoT (Internet of Things), home automation, and industrial automation. It provides a flexible and visual way to implement solutions that adhere to established standards. Here are a few examples of standards and protocols that Node-RED can work with:

- MQTT (Message Queuing Telemetry Transport): Node-RED includes MQTT nodes for publishing and subscribing to MQTT messages, which is a widely used lightweight messaging protocol in IoT. MQTT is a standard protocol. It was standardized by OASIS (Organization for the Advancement of Structured Information Standards), an international consortium that develops and maintains open standards for various industries.
- HTTP and REST APIs: Node-RED can interact with web services and RESTful APIs, which are often used for data exchange between IoT devices and cloud platforms. While it doesn't enforce these standards, it provides the tools to work with them.
- Modbus: In industrial automation, Modbus is a common protocol for communication between industrial controllers and devices. Node-RED has nodes for working with Modbus, allowing it to integrate with these systems.



- CoAP (Constrained Application Protocol): CoAP is a protocol designed for resource-constrained devices in IoT. Node-RED can be used to create CoAP clients and servers for communication with CoAP-enabled devices.
- JSON and MQTT-SN: Node-RED can work with JSON for data serialization and deserialization, which is commonly used for data exchange in IoT. It can also work with MQTT-SN (MQTT for Sensor Networks), an adaptation of MQTT for wireless and low-power devices.

Table 19 - MQTT description

Standard name	MQTT
Full name	Message Queuing Telemetry Transport
Version	5.0
Status	Released
Documentation	https://docs.oasis-open.org/mqtt/mqtt/v5.0/mqtt-v5.0.html
Ontology	[NOT APPLICABLE]
Formats	[NOT APPLICABLE]
Description	MQTT is an OASIS 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.
Maturity	MQTT has been widely adopted across various industries, including IoT, home automation, industrial automation, and messaging systems. Its widespread use indicates a high level of maturity.
Competitors	• CoAP (Constrained Application Protocol) • AMQP (Advanced Message Queuing Protocol) • HTTP • Proprietary Protocols
Use for the project	• Message exchange between different systems
Limitations	• MQTT is a stateless protocol, which means it doesn't maintain information about the client's previous interactions. While this is efficient, it may require additional application logic to manage state if needed. • MQTT offers security features, but their effectiveness depends on proper configuration. Inadequate security measures can expose MQTT networks to vulnerabilities.
Committees	• OASIS

LoRa, which stands for "Long Range," is a low-power, wide-area networking (LPWAN) technology designed for long-range communication between IoT (Internet of Things) devices. It enables devices to communicate



wirelessly over significant distances while consuming minimal power. LoRa is often used for applications such as smart cities, agriculture, industrial automation, and environmental monitoring.

LoRa (Long Range) is associated with the LoRa Alliance, an open industry association that has defined a standardized protocol called LoRaWAN (LoRa Wide Area Network). LoRaWAN is the networking protocol that operates on top of the LoRa physical layer, providing a standardized way for LoRa devices to communicate with network gateways and network servers. Here are some key points about LoRaWAN:

- **LoRaWAN Standard:** LoRaWAN is a well-defined and open standard for wide-area, low-power IoT communications. It specifies the communication protocol, data rates, security features, and network architecture.
- **Open Standard:** LoRaWAN is an open standard, meaning it is not controlled by a single company or organization. This openness promotes interoperability among LoRaWAN devices and network infrastructure from different manufacturers.
- **Security:** LoRaWAN includes security features such as end-to-end encryption and authentication to protect data transmitted between devices and network servers.
- **Scalability:** LoRaWAN supports the deployment of large-scale IoT networks, making it suitable for applications that require connecting a large number of devices.
- **Star of Stars Topology:** LoRaWAN networks typically use a "star of stars" topology, where individual devices communicate with nearby gateways, which, in turn, relay the data to a central network server.
- **Regional Parameters:** LoRaWAN operates in different frequency bands around the world, and regional parameters define the specifics of operation in each region to comply with local regulations.

The LoRa Alliance is responsible for maintaining and evolving the LoRaWAN standard. This alliance consists of various companies and organizations that collaborate to promote and develop LoRa technology and LoRaWAN. The standardization provided by LoRaWAN ensures that LoRa-based IoT devices can work seamlessly with LoRaWAN-compliant network infrastructure, facilitating interoperability and ease of deployment in various applications.

Table 20 - LoRaWAN description

Standard name	LoRaWAN
Full name	Long Range Wide Area Network
Version	1.0
Status	Released
Documentation	https://resources.lora-alliance.org/technical-specifications
Ontology	[NOT APPLICABLE]
Formats	[NOT APPLICABLE]
Description	The LoRaWAN® specification is a Low Power, Wide Area (LPWA) networking protocol designed to wirelessly connect battery operated ‘things’ to the internet in regional, national or global networks, and targets key Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility and localization services.
Maturity	LoRaWAN is a well-established open standard with a mature specification that defines the network architecture, device classes, data rates, and security features. LoRaWAN has been adopted globally, with networks and deployments in various countries. This wide adoption indicates a level of maturity in terms of its acceptance and utility.



Competitors	- Cellular IoT standards like Narrowband IoT (NB-IoT) and LTE-M (Long-Term Evolution for Machines) - Sigfox
Use for the project	Enable long range communication between devices on the construction site.
Limitations	- LoRaWAN has limited bandwidth, which is suitable for small data payloads but not for applications requiring high data rates or real-time communication. - LoRaWAN's outdoor coverage is generally good, but it may face challenges penetrating dense building structures, limiting its indoor coverage.
Committees	Lora Alliance

2.1.7.3 *Data Persistence Layer*

The Data Persistence Layer corresponds to the databases that store and connect all the information necessary for the correct operation of the system. These databases will include relational data model for storing static information, BIM models provided by the conception phases of the project or point clouds captured and processed by the UAV and dynamic data collected by the sensors.

In this context, BEEYONDERS consortium started considering the “Smart Data Models Initiative”: The FIWARE Foundation, TM Forum, IUDX and OASC are leading a joint collaboration initiative to support the adoption of a reference architecture and compatible common data models that underpin a digital market of interoperable and replicable smart solutions in multiple sectors, starting with Smart Cities.

A smart data model includes three elements: The schema, or technical representation of the model defining the technical data types and structure, the specification of a written document for human readers, and the examples of the payloads for NGSIv2 and **NGSI-LD** (see definition below) versions.

All data models are public and of royalty-free nature. The licensing mode grants 3 rights to the users:

- Free use
- Free modification
- Free sharing of the modifications

BEEYONDERS project partners will analyze the viability of contributing to the “Smart Data Models” initiative by analyzing existing models, proposing new open-source entities with our definition and schemas. Here is a strong opportunity for the project to contribute to the community and produce some standardization outcome.

NGSI-LD, which stands for Next Generation Service Interface - Linked Data, is a standard specification developed by the European Telecommunications Standards Institute (ETSI) for managing and exchanging information in the context of smart cities, IoT (Internet of Things), and other data-intensive applications. NGSI-LD is part of the larger NGSI (Next Generation Service Interface) initiative, which aims to provide a



common framework for handling data and context information in a more standardized and interoperable manner.

Here are key features and aspects of NGSI-LD:

- **Linked Data Principles:** NGSI-LD is designed to align with Linked Data principles, a set of best practices for publishing and connecting structured data on the web. Linked Data principles emphasize the use of standardized URIs (Uniform Resource Identifiers) to identify and link data, making it more discoverable and interconnected.
- **Semantics:** NGSI-LD includes semantic modeling capabilities, allowing data to be enriched with semantic information. This enables a common understanding of data semantics and enhances interoperability.
- **JSON-LD Format:** NGSI-LD uses JSON-LD (JSON for Linked Data) as its data interchange format. JSON-LD is a way of expressing linked data using JSON syntax, making it well-suited for web-based applications.
- **Context Information:** NGSI-LD focuses on managing context information, which includes real-time and historical data about entities in the environment. This can include information about devices, sensors, locations, events, and more.
- **Scalability:** NGSI-LD is designed to handle large-scale deployments of IoT devices and sensors, making it suitable for smart city applications where vast amounts of data need to be managed and analyzed.
- **Interoperability:** One of the key goals of NGSI-LD is to enable interoperability between different IoT systems, devices, and platforms. By adhering to standardized data formats and modelling practices, NGSI-LD promotes compatibility across diverse ecosystems.
- **Spatial and Temporal Data:** NGSI-LD supports the representation of spatial and temporal data, which is essential for applications like smart cities and environmental monitoring.
- **Real-Time Data:** NGSI-LD can handle real-time data, making it suitable for monitoring and reacting to changing conditions and events in smart city environments.
- **Open Standards:** NGSI-LD is an open standard developed through a collaborative process, which means that it is not controlled by a single vendor or organization. This promotes a level playing field for different stakeholders.

NGSI-LD has gained traction in the context of smart city initiatives, where it serves as a foundation for managing and making sense of the diverse data generated by IoT devices, sensors, and urban infrastructure. Its use of Linked Data principles and JSON-LD makes it suitable for web-based applications and integration with existing web technologies.

2.1.7.4 Robotics

One of the main challenges in BEEYONDERS project will be the management of the several types of robots implied in disruptive technologies we plan to implement: Autonomous vehicles, drones, exoskeleton, ... In order to integrate them in the BEEYONDERS Digital Twin Infrastructure, we consider using ROS.

ROS, which stands for Robot Operating System, is not actually an operating system in the traditional sense, but rather an open-source middleware framework used for developing and controlling robots. It provides a comprehensive set of tools, libraries, and conventions for building and managing robotic applications. ROS is widely used in robotics research, development, and industrial applications.



ROS has become the de facto standard in the field of robotics due to its flexibility, modularity, and extensive ecosystem. Researchers, developers, and companies use ROS to prototype, develop, and deploy a wide range of robotic systems, from research robots to industrial automation solutions.

ROS was developed and is maintained by a community of researchers, developers, and robotics enthusiasts. It was initially created by Willow Garage and is now managed by the Open Robotics organization. The development and evolution of ROS are community-driven and open-source.

This is a great opportunity for BEEYONDERS project not only to join and benefit from the work done by a large community of researchers, but to actively contribute with new use cases areas and robotics applications.

2.2 Identified committees

For each committee responsible of an identified standard, a template table has been filled in, and will be updated along the project, in particular the following fields:

- Membership: How can we become member of this committee?
- Contribution strategy: How would we contribute to this committee.
- Contributing partners: Which partners are already involved or plan to get involved, and what are their (actual or future) contributions.

Table 21 - CEN / TC-151

Standardization committee	CEN / TC-151
Type	-
Standards	- EN 474-1:2022: Earthmoving Machinery - Safety - Part 1: General Requirements. - EN 474-3:2022: Earthmoving Machinery - Safety - Part 3: Requirements for Loaders.
Web site	https://standards.iteh.ai/catalog/tc/cen/a744af22-01f2-49ad-9950-53d56133b148/cen-tc-151
Description	Standardization in the field of safety of machines and equipment used on construction sites, for winter service and highway maintenance as well as for the production and processing of mineral building materials. In exceptional cases glass machinery used outside the building material sector (e.g., laboratory glass machinery) is included.
Membership	• How to be part of it?
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• Which partner is already in this committee?



Table 22 - ISO / TC-127 description

Standardization committee	ISO / TC-127
Type	Standardization committee
Standards	ISO 17757:2019: Earthmoving Machinery and Mining - Autonomous and semi-autonomous machine system safety
Web site	https://www.iso.org/committee/52172.html
Description	Standardization of nomenclature, use classification, ratings, technical requirements and test methods, safety requirements, operation, maintenance manual format for earth-moving and related machinery.
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 23 - ISO/TC 110/SC 2 description

Standardization committee	ISO/TC 110/SC 2 Safety of powered industrial trucks
Type	Standardization committee
Standards	ISO 3691-4:2020 - Industrial trucks — Safety requirements and verification — Part 4: Driverless industrial trucks and their systems
Web site	https://www.iso.org/committee/51600.html
Description	Standardization in the field of power operated industrial trucks, hand-operated industrial trucks (including sack trucks, hand carts, trailers), all types of wheels and castors excluding those with pneumatic tyres and rubber solid tyres for pneumatic tyre rims, comprising safety requirements related to: • design and construction • testing and inspection methods • operation and maintenance
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 24 - EUROCAE WG-105 description

Standardization committee	EUROCAE WG-105
Type	Standardization committee
Standards	Not published



Web site	https://www.eurocae.net/about-us/working-groups/
Description	The Council of EUROCAE is responsible for approving the establishment of new Working Groups (WG) and for the definition of their work programmes, taking account of submissions made by any aviation stakeholder and in particular EUROCAE members. The Council reviews and approves all documents prior to their publication. The General Secretariat monitors the WG activities, and has initiated the Chairperson's Club to provide the Chairpersons and Secretaries with an opportunity to learn more about EUROCAE's procedures.
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 25 - ISO/TC 20/SC 16 description

Standardization committee	ISO/TC 20/SC 16 – Unmanned aircraft systems
Type	Standardization committee
Standards	• ISO 23629-5:2023 UAS traffic management (UTM) — Part 5: UTM functional structure. • ISO 21384 series – Unmanned aircraft systems (UAS)
Web site	https://www.iso.org/committee/5336224.html
Description	Standardization in the field of unmanned aircraft systems (UAS) including, but not limited to, classification, design, manufacture, operation (including maintenance) and safety management of UAS operations.
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 26 - ISO/IEC Joint Technical Committee JTC 1/SC 35 description

Standardization committee	ISO/IEC Joint Technical Committee JTC 1/SC 35
Type	Standardization committee
Standards	- ISO/IEC 30071-1:2019 – Information technology — Development of user interface accessibility — Part 1: Code of practice for creating accessible ICT products and services
Web site	https://www.iso.org/committee/45382.html



Description	Standardization in the field of user-system interfaces in information and communication technology (ICT) environments and support for these interfaces to serve all users, including people having accessibility or other specific needs, with a priority of meeting the JTC 1 requirements for cultural and linguistic adaptability.
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 27 - ISO/TC 199 – Safety of machinery description

Standardization committee	ISO/TC 199 – Safety of machinery
Type	Standardization committee
Standards	- ISO 12100:2010 – Safety of machinery — General principles for design — Risk assessment and risk reduction
Web site	https://www.iso.org/committee/54604.html
Description	Standardization of basic concepts and general principles for safety of machinery incorporating terminology, methodology, guards and safety devices within the framework of ISO / IEC Guide 51 and in cooperation with other ISO and IEC technical committees.
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 28 - ISO/TC 159/SC 3 description

Standardization committee	ISO/TC 159/SC 3 – Anthropometry and biomechanics
Type	Standardization committee
Standards	- ISO 11228-2:2007 Ergonomics — Manual handling — Part 2: Pushing and pulling - ISO/AWI 11228-3 Ergonomics — Manual handling — Part 3: Handling of low loads at high frequency [Under development]?
Web site	https://www.iso.org/committee/53362.html
Description	Standardization in the field of ergonomics/human factors for anthropometry and biomechanics, including measurement methods for the human body, evaluation methods for working postures, physical



	performance and strength, and the ergonomic procedures needed to apply them. Recommendations are made for terminology, methodology and the collection of ergonomics/human factors data for the purpose of realizing human safety, health and wellbeing, as well as increasing work efficiency and usability.
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 29 - ISO/TC 261 description

Standardization committee	ISO/TC 261 Additive manufacturing
Type	Standardization committee
Standards	- ISO/ASTM 52950, Additive manufacturing — General principles — Overview of data processing
Web site	https://www.iso.org/committee/629086.html
Description	Standardization in the field of Additive Manufacturing (AM) concerning their processes, terms and definitions, process chains (Hard- and Software), test procedures, quality parameters, supply agreements and all kind of fundamentals.
Membership	• [To be evaluated]
Dynamism / activity	• [Not known]
Contribution strategy	• [Not known]
Contributing partners	• [To be checked]

Table 30 - bSI description

Standardization committee	buildingSMART International
Type	BIM Pre-standardization
Standards	IFC, IDM, MVD, BCF, bSDD.
Web site	https://www.buildingsmart.org/
Description	buildingSMART is the worldwide industry body driving the digital transformation of the built asset industry. buildingSMART is committed to delivering improvement by the creation and adoption of open, international standards and solutions for infrastructure and buildings. buildingSMART is the community for visionaries working to transform the design, construction, operation and maintenance of built assets.



	buildingSMART is an open, neutral and international not-for-profit organization.
Membership	• Membership in buildingSMART International is open to companies, government bodies and institutions from around the world. buildingSMART International offers three levels of membership. Membership is required for those parties wishing to take an active role in the development of solutions to user or technical requirements. bSI members have voting rights in the standards committee. • Some partners of BIGG project are buildingSMART members: CSTB, ...
Dynamism / activity	• Very active on standard evolution • 2 international Summits per year, plus tens of specific meetings • Several new emerging project every year
Contribution strategy	• Become a member of bSI or local chapter. • Attend BIGG-related Working groups or Rooms meetings. • First to get information about the standards. • Later to i) promote the use of standards in BIGG project, ii) suggest some modification/improvement of the standards, and iii) initiate the development of new standards.
Contributing partners	• CSTB: ○ Member of buildingSMART France ○ Participation in several working groups (to be detailed) ○ Participation to biannual bSI Technical Summit • [Partner]: ○ [Contribution actions]

2.3 Identified initiatives

[Remark] No interesting initiative have been identified so far. This part will be updated during the rest of the project.

2.4 Identified “sister projects”

[Remark] The relation with sister projects will be handled in task 8.5 (Liaison activities). We'll see in the next months if we develop a specific part here dealing with standardization aspects, or if the relation with sister project is integrally developed in the scope of task 8.5.



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BEEYONDERS project partner ICONS has started to build a collaboration with a couple of sister project: Robétarmé and Humatech. The first objective of this collaboration is to organize a conference in the next ERF event in 2024. Contacts has also been taken to explore possible joint standardization activities.

3 Notes about the next steps and future version of the document

Task T8.6 will be going on until the end of the project, aiming at developing the next phases of our “contribution to standardization” strategy. These phases are:

- Phase 2 & 3 – Adopting and using the standards. Main actions in this phase will be:
 - Participation to standardization committees: adopt the identified standard by participating to standardization events, committees’ meetings, domain conferences, etc. By attending these events, partners can provide interesting inputs about standards, use cases, future evolution to the whole consortium.
 - Implementation of standards: use the standards in the technical developments of the project and identify the potentially “standardizable” outcomes. A specific focus of this task will be to pay particular attention to how we are facilitating partners access to the standards that have been found out and be integrated in their work.
- Phase 4 – Contributing to standardization: this last phase aims at actively contributing to the standardization world. All-important achievements of the project relative to standardization should be made public, presented, and demonstrated to the standardization community. We’ve identified four main types of active contribution:
 - Creation of a “Standardization sister projects community”
 - Demonstrating standard use
 - Suggesting standards modification / extension / linking
 - Submitting new standards

Finally, at the end of the project, we will produce an Experience Feedback about standardization, explaining how we manage (or not) to have an efficient standardization activity during the project, and listing important standards related to innovative technologies for building sites.

