humantech

D2.4 - bSDD specification from BIMxD

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Acronyms and definitions

Acronym	Meaning
2D/3D	Two/Three Dimensional
AR	Augmented Reality
BCF	BIM Collaboration Format
BIM	Building Information Modeling
BIMxD	Extended Dynamic BIM
bSDD	builsingSmart Data Dictionary
DSDT	Dynamic Semantic Digital Twin
HT	HumanTech
IDM	Information Delivery Manual
IDS-RAM	IDS Reference Architecture Model
IFC	Industry Foundation Classes
PCD	Point Cloud Data
RGB-D	Red, Green, Blue plus Depth
ROS	Robot Operating System
UAV	Unmanned Aerial Vehicle
UC	Use Case
UGV	Unmanned Ground Vehicle
VR	Virtual Reality
WP	Work Package
XR	Extended Reality

Abstract

This document, deliverable 2.4 is the first results of the analysis of the openBIM standards for the proposal of an IFC extension using bSDD. It provides an analysis of the advancements in interoperability and openBIM standards within the construction industry within the domain of the HumanTech Project. It explores the critical role of interoperability in integrating diverse systems and the transformative impact of openBIM over traditional closed BIM methodologies. The document delves into buildingSMART's openBIM standards, emphasizing the importance of standards such as IFC and bSDD in facilitating information exchange. It also examines the standardization process for interoperability and highlights the integration of innovative elements like robotics and safety protocols through the HumanTech project. The conclusion addresses the need for ongoing adoption and adaptation of evolving openBIM standards and the future steps of the task T2.4.

Executive Summary

The first chapters 1. Introduction explores two main important themes in the extension of the IFC standards:

1.1. Interoperability: This section explores the ability of various construction systems and applications to exchange and utilize information. It highlights how interoperability is fundamental in integrating geometric and descriptive data from BIM authoring software into various project phases, enhancing collaboration among stakeholders and ensuring continuity of information throughout a project's lifecycle.

"1.2. The Concept of OpenBIM: The section discusses the evolution of BIM into a comprehensive framework that supports the digital twin of the built environment. It details an interoperability framework within the EU, covering legal, organizational, semantic, and technical aspects, and how each layer influences BIM methodology and its development.

2. OpenBIM Standards: This part delves into buildingSMART's openBIM standards, focusing on their role in ensuring open information exchange within BIM processes. It discusses the importance of standards like IFC, MVD, bSDD, IDM, and BCF in defining data models and facilitating information exchange in construction. Highlighting why they are important in the HumanTech standardisation activities

4. HumanTech and openBIM standards: This part highlights the HumanTech project's efforts in aligning construction requirements across various phases with the integration of robotics and human activities. It emphasizes the project's use of openBIM standards and the creation of the HumanTech dictionary within bsDD.

5. Conclusion and Next Steps" The final section summarizes the document's insights and anticipates future directions of the task T2.4 emphasizing the ongoing need for adopting and adapting to evolving openBIM standards within the HumanTech domain

The HumanTech project

The European construction industry faces three major challenges: increase the safety and wellbeing of its workforce, improve its productivity, and become greener, making efficient use of resources.

To address these challenges, HumanTech proposes to develop **human-centred cutting-edge technologies** such as wearables for workers' safety and support and robots that can harmoniously coexist with human workers while contributing to the ecological transition of the sector.

HumanTech aims to achieve major advances in cutting-edge technologies that will enable a safe, rewarding, and digital work environment for a new generation of highly skilled construction workers and engineers.

These advances will include:

- **Robotic devices equipped with vision and intelligence** that allow them to navigate autonomously and safely in highly unstructured environments, collaborate with humans and dynamically update a semantic digital twin of the construction site in which they are.
- **Smart, unobtrusive workers protection and support equipment**. From exoskeletons activated by body sensors for posture and strain to wearable cameras and XR glasses that provide real-time workers' location and guidance for them to perform their tasks efficiently and accurately.
- An entirely new breed of **Dynamic Semantic Digital Twins (DSDTs) of construction sites** that simulate in detail the current state of a construction site at the geometric and semantic level, based on an extended Building Information Modelling (BIM) formulation that contains all relevant structural and semantic dimensions (BIMxD). BIMxDs will act as a common reference for all human workers, engineers, and autonomous machines.

The **HumanTech consortium** is formed by 22 organisations — leading research institutes and universities, innovative hi-tech SMEs, and large enterprises, construction groups and a construction SME representative — from 10 countries, bringing expertise in 11 different disciplines. The consortium is led by the German Research Center for Artificial Intelligence's Augmented Vision department.

Contents

1. Introduction

Expanding existing standards within the construction sector plays a pivotal role in effectively managing both construction and demolition phases, as underscored in the HumanTech project. This endeavour encompasses the integration of comprehensive data concerning robotic elements, encompassing their qualitative and quantitative attributes. Of particular significance is the seamless integration of this data into HumanTech's BIMxD platform. This strategic approach, meticulously cultivated in the project's Work Package 2 (WP2), involves an in-depth analysis of the current state of openBIM standards, coupled with their augmentation to enhance comprehensibility across diverse stakeholders within the construction domain.

Standardization and harmonization of this enriched data hold paramount importance, serving as the linchpin for optimizing the synergy between robots and human workers within Building Information Modeling (BIM) processes. This harmonious integration promises to propel the construction sector towards significant advancements in innovation and modernization, ultimately reshaping the industry's landscape.

1.1. Interoperability

The term "interoperability" refers to the ability of different systems, networks, devices, applications, or components to exchange and utilize information. It plays a fundamental role in Building Information Modeling (BIM), allowing the integration of both geometric and descriptive data initially defined in BIM authoring software into various workflow processes, aligning with specific model uses and objectives.

Interoperability addresses three vital technical requirements. Firstly, it facilitates information exchange among diverse stakeholders during project phases, like the design phase where architects and engineers contribute data for quantity estimation. Secondly, it ensures the continuous use of information throughout project stages, spanning from initial design to demolition. Thirdly, it enables access to archived data throughout an asset's lifecycle, even when the original software is obsolete.

In an age of increasing specialization among stakeholders, there is a risk of fragmented information exchange. However, digital technologies offer the potential to streamline these exchanges, enhance expertise, and simplify communication. Traditional project and management communication methods have been replaced by software tools, which have faced communication limitations, resulting in what's been referred to as the "Island of Automation" since the 1990s.

1.2. The Concept of OpenBIM

In the dynamic realm of construction and infrastructure development, effective specialization demands adaptability and a shared vision to overcome potential challenges. What commenced as a modest endeavor in product and process modeling has since evolved into a sweeping concept that transcends traditional Building Information Modeling (BIM). Today, BIM serves as the bedrock for what is now termed the Digital Twin of the built environment, a pivotal element within the framework of Industry 4.0.

To facilitate interoperable public information services across the European Union, an extensive interoperability framework has been established, encompassing four layers: legal, organizational, semantic, and technical. In this specific context, each of these layers plays a crucial role in shaping BIM methodology and its ongoing evolution. Legal considerations revolve around the legislative landscape in different states, indirectly influencing operational aspects governed by organizational, semantic, and technical levels. Organizational layers provide clarity on how information requests are exchanged among service providers, delineating responsibilities and expectations. Semantic layers ensure the meaningful interpretation of data and semantic information through well-defined concepts (entities, properties, etc.) and their relationships, facilitated by the use of ontologies (data dictionary bSDD). These semantic considerations are intricately connected to technical standards, which dictate data structures for entities, geometries, associated properties, and classifications, thereby ensuring seamless object-based data exchange.

In the ever-evolving landscape of construction and infrastructure development, the adoption of innovative technologies is imperative for maintaining a competitive edge, mitigating risks, and ensuring the successful execution of projects. One such innovation that has gained substantial traction in recent years is openBIM, a paradigm shift that is revolutionizing our approach to Building Information Modeling (BIM) and data management within the AECO (Architecture, Engineering, Construction, and Operations) industry.

OpenBIM, short for "Open Building Information Modeling," represents a fundamental departure from the traditional closed BIM methodologies that have held sway in the industry for decades. At its core, openBIM embodies a collaborative, standards-based approach to designing, constructing, and managing building and infrastructure projects. It places a premium on the use of open standards and formats, ensuring that data is not confined to a single proprietary software or platform. Instead, it facilitates eamless data exchange among different BIM software applications, fostering greater interoperability and mitigating the risk of data silos.

1.2.1. Key Differences from Closed BIM

To fully appreciate the significance of openBIM, it's essential to contrast it with closed or proprietary BIM approaches:

Vendor Neutrality: Closed BIM solutions often tie users to a specific software vendor, limiting flexibility and collaboration. In contrast, openBIM encourages vendor neutrality, enabling project stakeholders to select the best software tools for their specific tasks while maintaining data compatibility.

Interoperability: Closed BIM systems struggle with interoperability issues, making it challenging to share and integrate data with external parties. openBIM prioritizes interoperability, allowing various stakeholders to work together seamlessly, regardless of the software they use.

Data Transparency: openBIM promotes data transparency throughout a project's lifecycle. Unlike closed BIM systems, where information can be locked within proprietary formats, openBIM ensures that project data remains accessible and transparent, fostering better decision-making and risk management.

Collaboration: Closed BIM often creates information silos, hindering collaboration among architects, engineers, contractors, and facility managers. openBIM breaks down these silos, facilitating real-time collaboration and reducing errors, which can result in cost and time savings.

Long-Term Viability: Closed BIM solutions may face obsolescence as software providers evolve or discontinue their products. openBIM, rooted in open standards, offers greater assurance of long-term viability and adaptability.

1.2.2. Benefits of openBIM

The adoption of openBIM brings a multitude of benefits to construction and infrastructure projects:

Enhanced Collaboration: openBIM encourages multidisciplinary collaboration, enabling project stakeholders to work together seamlessly, leading to improved project coordination and communication.

Reduced Errors and Rework: By ensuring data consistency and transparency, openBIM helps in identifying and resolving issues early in the design and construction phases, reducing costly errors and rework.

Improved Data Accessibility: With data stored in open formats, project data remains accessible and adaptable throughout the project's lifecycle, supporting efficient facility management and maintenance.

Flexibility in Software Choices: openBIM allows organizations to select software tools that best suit their needs and budget, eliminating vendor lock-in and fostering innovation.

Cost and Time Savings: By streamlining processes, minimizing errors, and improving collaboration, openBIM can lead to significant cost and time savings on construction and infrastructure projects.

2. OpenBIM Standards

2.1. buildingSmart's OpenBIM Standards

As mentioned earlier, BIM models for infrastructure must be exchanged using open formats. The main reasons for this are summarized below:

- Often, these are public works, the first to be involved in the legislative process, also regarding the contractual base amount.
- The BIM experience, partly inherited from buildings, reveals that an information exchange hierarchy based on open standards is more effective and productive over time.

The ISO 16739 standard defines Industry Foundation Classes (IFC) as the international standard for achieving open information exchange within BIM processes. IFC is a data model that aims to revolutionize the construction industry by transferring Information Technology techniques, with a particular focus on databases. The same processes that generated it are still ongoing, allowing IFC to be seen as a constantly changing and expanding universe, as seen in the infrastructure domain between 2018 and 2021 (bridges, roads, railways, ports), and for the development of other infrastructures (airports, tunnels) in the coming years, enabling a more comprehensive description of the built environment.

However, the mere definition of a data model does not fulfil the needs of a complex industrial sector like construction. For this reason, buildingSmart International articulates its information standard into five constituent elements:

- A data model (Industry Foundation Classes - IFC).
- A method for determining portions of the data model to meet specific uses (Model View Definition - MVD).
- A common dictionary defining properties (buildingSmart Data Dictionary - bSDD).
- A standard process to uniquely define information exchange requirements (Information Delivery Manual - IDM).
- A standard format for communicating product or process issues (BIM Collaboration Format - BCF).

The importance of having a standard available and the value of the cultural capital it conveys lead to the understanding that these tools should become a standard practice. They can be easily implemented in private company workflows, even with proprietary platforms.

If these are the five pillars defining the core of the openBIM structure, two other standards are in the final stages of development. The first is the Information Delivery Specification - IDS, which allows for the definition of specific informational exchange requirements to make them computationally interpretable, and the second standard pertains to openCDE APIs, which aims to improve interoperability between platforms and ecosystems in the AEC sector through uniformity in Application Programming Interfaces within Common Data Environments. Finally, as a service, Use Case Management - UCM has been implemented for defining customized exchange scenarios specified in the IDM.

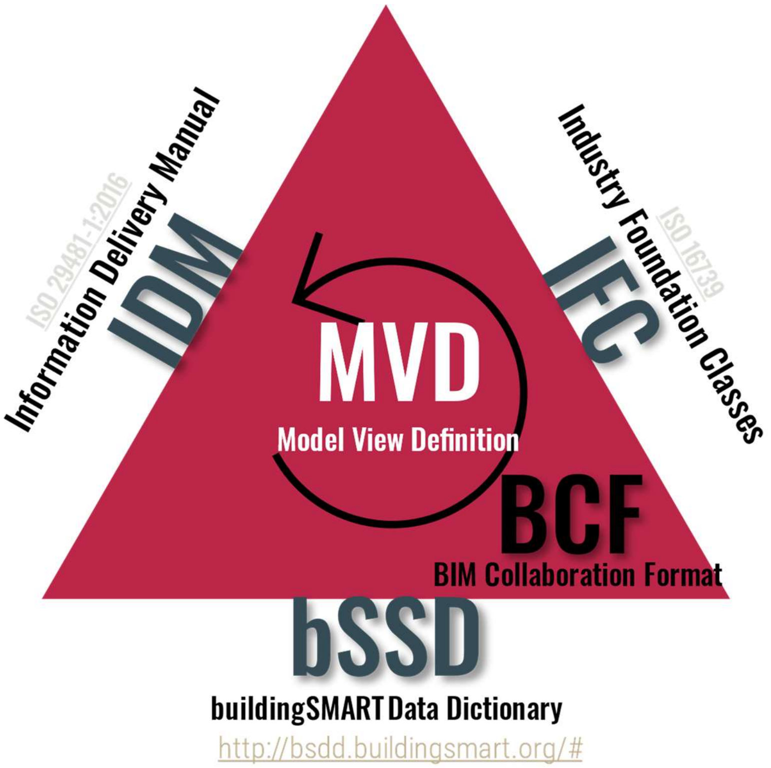

Figure 1 Organization of standards developed by buildingSmart International. (Credit R.A. Bernardello, adapted from buildingSmart Int)

3.2.2. The Standardization Process for Interoperability

The first aspect of standardization is achieved through a breakdown of processes that allow the description of specific information exchanges occurring in the construction industry. To adequately translate the IFC data model into individual activities and to facilitate and make the implementation and management of the same data model in various software applications in the construction industry more sustainable, two standards have been implemented: the Information Delivery Manual (IDM) and the Model View Definition (MVD).

The IDM, as the name suggests, defines the minimum rules for documenting information exchange between at least two software applications.

The MVD, on the other hand, in its literal translation as "Model View Definition," serves a dual purpose: it defines a subset of the IFC data model for predefined workflows to reduce the amount of exchanged information, thereby enhancing the operability of models. Secondly, it serves as the computational translation of one or more IDMs.

IDM

In a chronological context, starting from a real scenario in which informational requirements need to be exchanged between parties, the IDM enables the mapping of this flow through well-defined steps. As it serves as a method to transition from the real scenario to the specific grouping of informational requirements, an IDM allows for the description of business needs. In ISO 19650 regulations, these business needs encompass the objectives of the organization, asset, and individual project. The IDM describes individual procedural activities, transitions, and specific informational requirements for each transaction. Since it is a process, some of the operations related to IDM formulation pertain to project management and the flows between actors involved in the same scenario.

To define an IDM, the first step is to establish specific model uses (or use cases), literally what needs to be accomplished through the use of informational models. Starting from these use cases, a Process Map is created, visually representing the information flow. Standardized using the Business Process Model and Notation (BPMN) method, this map defines actors and roles, temporal phases, "data objects" such as documents, deliveries, and the models themselves, as well as triggered events, decisions, and alternative flows. Use cases can vary significantly, with some having highly detailed process maps and very specific scenarios (Fig. 6). In other cases, they may be defined to represent broader and more general exchange scenarios (Fig. 7). These use cases can address both theoretical processes or be more closely related to individual contracts or company activities.

On the Process Map, individual data objects are defined, containing the requests and informational contents that must be shared according to specific timing and methods. By definition, an Exchange Requirement is a concise and non-technical description of information transferred at a specific project stage. Typically, these are defined in a table specifying the required object types, their geometric representation, spatial containment structure, and relationships with other objects. Operationally, informational requirements are common in BIM practice, such as defining a set of customized parameters that include properties requested by the client, such as project or construction site work breakdown structure (WBS). However, the procedure described above is used to generally identify all informational contents, including graphical representation.

MVD and IDS

If exchange requirements consist of individual pieces of information exchanged for a specific reason, they can be correctly mapped into the IFC data structure. Since the BIM model will involve multiple use cases, and therefore multiple exchange requirements, not all information contained in the data model will be necessary. MVDs are used to highlight only that set of classes and properties required.

In IFC 2x3 and IFC4, MVDs have been specified and approved by buildingSMART (bSI) over time to support software in the export and import phases. It should be noted that once software is certified, it only implements a sufficient number of MVDs (see Table 1). The possibility of independently implementing one's own MVD is not pursued except for some academic cases, due to the significant complexity of implementation and the difficulty of making it operational in software.

Schema	Name	Purpose
IFC4	Reference view (Architectural / Structural / MEP Reference exchange)	Discipline-specific information: architectural, structural, etc.
IFC2x3	Coordination view (Architectural / Structural / MEP Reference exchange)	Discipline-specific information: architectural, structural, etc.
IFC2x3	Structural analysis view	Structural analysis: analytical elements, loads (point, linear, distributed), constraints, section information, etc.
IFC2x3	Basic FM Handover view	Facility management: inventory data, etc.
IFC2x3	Space Boundary Addon view	Spatial boundaries

Table 1 MVDs of IFC 2x3 and IFC4 versions with "final" status from buildingSmart

To address this complexity for both users and software companies, and considering the growing need, driven by increasingly extensive projects and specialization of stakeholders, to define specific informational requirements, buildingSMART is developing the aforementioned Information Delivery Specifications (IDS). IDS is a collection of specifications designed to link a specific informational requirement to a verifiable and applicable condition. If the condition is not met or incomplete, the requirement is ignored. The connection with other standards, both IFC and bSDD, allows for the customization of information exchange.

IDS defines informational exchanges as follows:

*"**All entities X (of class/type Y), having attribute/classification/property/material Z,** must have attribute/class/classification/property/material/type (...) and/or be part of (...)."*

The first part of the specification (in bold and Italic) is the context in which the specification must be met, while the blue part determines the requirement. An example of a specification is as follows:

*"**All pile stems with ObjectType .PIERSTEM.** must have an IfcPropertySingleValue property named 'Environmental Exposure Class' contained in the custom property set 'P_Environmental.'"*

BCF

The BIM Collaboration Format (BCF) is used to facilitate communication among project stakeholders regarding issues, requests for clarification, and concerns that arise in connection with the BIM model. BCF associates a viewpoint and snapshot with descriptive data, involved parties, a responsible entity, and a deadline for resolution, all tied to a specific issue occurring within the model. This helps prevent inaccuracies and errors that may result from informal or text-based communication.

Once an issue is defined in BCF, the corresponding file (.bcfzip) is transferred from one user to another, edited, and then returned. BCF files can be "bounced" between multiple parties, as long as all parties maintain the integrity of the shared BCF file and do not distribute additional copies of it.

In addition to the file-based workflow, there is an API-based method using web services (RESTful) for BCF. This involves implementing a BCF server, which stores all BCF data and allows project participants to synchronize the creation, modification, and management of BCF topics in a centralized location.

IFC

The Industry Foundation Classes (IFC) is a data model used for the effective definition of a BIM (Building Information Modeling) project and the construction of a model that consistently represents the shape of the reference asset. It particularly focuses on ontological concepts, such as attribute inheritance, spatial and functional relationships, among others, within the scope of representation. The deterministic nature of the data model leads to the production of interoperable information models capable of shaping the asset's form while optimizing the quality of the final result based on the objectives to be met and how the model needs to be queried. Within the technical interoperability in BIM systems, where objects are central to the processes, whether they represent construction components or serve as references for management data (e.g., COBie), the definition of what and how information is exchanged forms the basis of openBIM standards.

The data model itself is known as IFC, which describes the geometry, attributes, and characteristics of objects while replicating real-world relationships. Its intention is to be applied to various domains within construction, expanding its coverage from building construction to many infrastructure domains, encompassing the entire lifecycle of the built asset. While initially, the IFC data schema was primarily used for architectural purposes, it has since been expanded to include various infrastructure domains such as bridges, roads, railways, and ports. The goal is to create a unified and shared standard that eliminates inconsistencies in the IFC schema, which was previously focused mainly on building construction. This aims to facilitate the exchange and understanding of shared information, ultimately aligning with fundamental sustainability principles to support a sustainability system.

However, it's essential to recognize that different infrastructure domains have inherent distinctions. Therefore, the approach to defining the data schema for a bridge, for example, differs from that of a road or port. While it's clear that the elements of the data model are ontologically distinguishable, it requires careful consideration and analysis to determine the logic of the model. This logic is derived from mechanical modeling, enabling the designer to break down the infrastructure into assembly objects or part objects, each with assigned geometric constraints, properties, manufacturing methods, calculation methods, and more. This same logic aims to apply to designers in each infrastructure domain.

The approach to be provided focuses on understanding shared dynamics that are applicable in multiple cases and those that require specific analysis. The latter will be detailed and exemplified concerning roads and, particularly, bridges.

The IFC standard structures the data schema with a lexicon and terms that have precise meanings and, consequently, specific behavioral actions within the data model itself. Some fundamental concepts include:

- Entity: Represents any concept, abstract or concrete, characterized by constraints and attributes.
- Attribute: The minimum unit of information for each entity.
- Instance: The materialization, either physical or abstract, in the digital model of a specific entity. It represents one of the objects in the exported model and is synonymous with occurrence.
- Property: A unit of information associated with each instance.

In addition to these concepts, there is the notion of a concept template, which represents how IFC operates within the scenarios of BIM model usage. It connects the class to key themes (typification methods, aggregation methods, association with a geometric representation, etc.) to ensure functional-spatial, performance, and geometric description.

bSDD

The BuildingSMART Data Dictionary (bSDD) is a comprehensive and standardized terminology and data classification system used within the field of Building Information Modeling (BIM) and construction industry. It provides a structured and organized framework for defining and managing data associated with construction projects and built assets. The bSDD serves as a common language that facilitates effective communication and data exchange among various stakeholders involved in the construction and building management processes.

2.2. IFC and bSDD

The construction and building industry have witnessed a transformative shift in recent years, thanks to the advent of Building Information Modeling (BIM). At the heart of this digital revolution lies the Industry Foundation Classes (IFC), a data model that forms the backbone of BIM processes. IFC serves as the common language for representing and exchanging information related to construction and infrastructure projects. However, to harness the full potential of BIM and IFC, it has become imperative to enhance data richness, semantics, and interoperability.

Enter the BuildingSMART Data Dictionary (bSDD), a powerful companion to IFC that elevates the capabilities of BIM to new heights. bSDD is a standardized and comprehensive repository of terms, definitions, and data classifications specifically tailored to the construction industry. Its integration with IFC extends the model's semantic depth and brings structured data management to the forefront.

With bSDD, construction professionals can achieve greater clarity and precision in data representation. It provides a standardized vocabulary that ensures consistent terminology usage across projects, reducing ambiguity and misinterpretation. This semantic richness not only enhances data understanding but also facilitates seamless collaboration among project stakeholders.

One of the key benefits of combining IFC and bSDD is improved interoperability. The integration ensures that different BIM software applications can communicate effectively, as they share a common understanding of data semantics. This compatibility streamlines data exchange and reduces errors, enabling project teams to work more cohesively.

Furthermore, bSDD introduces structured data classification, allowing users to categorize and manage information efficiently. This structured approach simplifies data organization, retrieval, and utilization, contributing to more streamlined and productive project workflows.

Consistency is another hallmark of bSDD integration. Standardized rules and relationships between data elements maintain data integrity throughout the project lifecycle. This consistency minimizes discrepancies and misunderstandings, ultimately leading to higher-quality project outcomes.

In alignment with industry standards and openBIM principles, both IFC and bSDD empower construction professionals to harness the full potential of digital transformation. This integration sets the stage for more sophisticated, collaborative, and efficient construction practices, ushering in a new era of innovation and excellence in the construction and building industry.

In this exploration, we delve deeper into the significance of extending IFC through bSDD and the multiple ways in which this integration shapes the future of construction and infrastructure projects.

3. Bridging the Gap: Addressing Limitations in OpenBIM Standards

Notable limitation exists in the current OpenBIM standards, particularly in the prevailing practice of exporting authored BIM models into IFC (Industry Foundation Classes). The activities of the WP2 and in particularly of the task T2.4 delves into the identified lack of bidirectional communication, the absence of integration with robotic technologies and in the workflows that involved them, highlighting the need for industry-wide improvements. Following some of the most challenging difficulties are highlighted:

Addressing Misconceptions: OpenBIM Beyond IFC Export: Some users may mistakenly perceive openBIM as merely exporting IFC files, overlooking the broader collaborative standards. openBIM encompasses a range of interoperability standards beyond IFC, promoting bidirectional data exchange and interconnected workflows for real-time collaboration throughout the project lifecycle. Embracing these comprehensive standards, such as bSDD and others, goes beyond exporting and unlocks the full potential of openBIM, fostering efficiency, accuracy, and improved project outcomes. Educating users about the holistic nature of OpenBIM encourages a more informed and collaborative approach within the architecture, engineering, and construction industry.

Robotic Technologies and IFC Standards: A significant gap exists in OpenBIM regarding the integration of robotic technologies with Industry Foundation Classes (IFC) standards, hindering the industry from fully capitalizing on the efficiency and innovation that robotics can bring to construction processes. The lack of mutual understanding between the robotic side and IFC standards poses challenges in seamless collaboration. Bridging this knowledge gap is essential to unlock the potential of automation, enabling more precise, faster, and adaptable construction workflows. Collaboration between the robotics and AEC communities is crucial for developing standards that accommodate the specific requirements of robotic technologies while ensuring interoperability in the construction sector. Closing this gap is imperative for fostering a more cohesive and advanced construction ecosystem, and the aim is to starts from the HumanTech results and products.

Evolution of IFC Standards: The IFC standards have evolved over the years, with versions now official IFC 2x3, IFC 4ADD2, and IFC 4.3 progressively implementing and expanding the descriptions of building elements. Despite these advancements, a substantial number of practitioners continue to use the outdated IFC 2x3 standard. This practice implies that many in the industry are adhering to standards that may not fully capture the intricacies of modern AEC construction requirements. The latest IFC version stands as a testament to the exhaustive description of building elements within the OpenBIM framework. However, the industry must actively engage with and adopt these latest standards to ensure that projects are represented accurately and comprehensively.

Encouraging the widespread use of the most recent IFC standards will contribute to a more standardized, interoperable, and future-proof OpenBIM ecosystem.

Name	Published	Current Status	EXPRESS	XSD	OWL HTML	RDF
IFC 4.3 ADD2	2023-09	ISO approved	EXP	XSD	-	-
IFC4 ADD2 TC1	2017-10	Official	EXP	IFC4.xsd	ifcOWL IFC4 ADD2 TC1	RDF
IFC2x3 TC1	2007-07	Official	EXP	IFC2X3.xsd	ifcOWL IFC2x3 TC1	RDF

IFC file extension: The format predominantly used for sharing IFC is the EXPRESS file, with other formats being adopted to a lesser extent. This implies a lower dissemination of information within the model, as the EXPRESS file is the prevailing method of sharing. The predominant choice of this format might limit the accessibility and widespread sharing of data, as some users may not be able to interpret or use less commonly adopted formats. Exploring different formatting options could promote greater interoperability and information sharing within the OpenBIM ecosystem.

The ongoing technical changes in buildingSMART's standards and services are undeniably crucial, yet they present significant challenges for those tasked with implementing and adapting to them. These updates are vital for advancing the efficiency, interoperability, and sustainability of construction projects, signifying a progressive step in the AEC industry. However, the transition to these enhanced standards, such as the updated IFC, bSDD and IDS demands a considerable investment in terms of training, software upgrades, and changes to existing workflows.

Addressing the limitations in OpenBIM standards requires a collective effort from industry stakeholders. By promoting bidirectional communication, integrating robotic technologies, and advocating for the adoption of the latest IFC standards, the AEC sector can usher in a new era of collaborative and technologically advanced practices. It is crucial for professionals to stay informed and embrace evolving standards to fully unlock the potential of OpenBIM in shaping the future of construction.

4. HumanTech and openBIM standards

The HumanTech project's distinctive feature lies in its need to engage with the construction industry, presenting a core challenge in harmonizing the requirements of construction across various phases, particularly in the creation of BIM models and digital surveys. The aim is to connect these needs with the realms of robotics and human activities. To ensure the widespread adoption and adaptability of HumanTech project outcomes, extending beyond its immediate scope and accommodating diverse pipelines, adherence to standardized protocols is essential. This is facilitated through the utilization of openBIM standards, notably in crafting the HumanTech dictionary within the bsDD. This specialized dictionary serves to comprehensively capture and articulate object descriptions, including their characteristic information and how they intricately connect with the construction model within IFC. Furthermore, it details how these objects relate to other entities within the construction site. Through a meticulous analysis of buildingSMART products, strategic implementation approaches have been determined to seamlessly integrate these crucial elements.

After an in-depth analysis and discussion with the other technical WP, the conclusion is that there are five main topics that has to be expanded and integrated in the IFC and larger openBIM. These are markers, workers, robots, mission plannings, falling hazards. This comprehensive strategy is not just about incorporating new elements into the bSDD; it's about redefining and enhancing the way the robotic in construction industry operates, using the principles of digital transformation and standardization.

Markers are more than mere physical reference points in a digital survey. They are conceptualized as data-rich elements capable of interacting with digital models and real-world coordinates. These markers facilitate a precise alignment between digital plans and physical construction, effectively bridging the gap between virtual designs and their real-world execution. Such integration ensures a high level of accuracy and efficiency in transforming designs into tangible structures. Building on the foundation laid by CWA 18046:2023, which provided a standardized approach for using markers on-site, the next step involves translating these standards into the bsDD format. This transformation is crucial for enhancing the utility and effectiveness of markers in modern construction projects.

Workers: Although the Industry Foundation Classes (IFC) framework allows for the description of intangible objects, this feature is not widely utilized in standard practices. The aim, therefore, in the HT bSDD, is to comprehensively describe the various professional roles active on construction sites. This detailed characterization will facilitate their recognition in processes such as reconstruction, demolition, and in their interactions with robots on the BIMxD platform. By doing so, it enhances the practical application and relevance of non-material object descriptions in the construction industry.

Robots and Automated Systems: Enhancing the previous translation, it's important to emphasize the role of robots in the modern construction landscape and the necessity for their detailed categorization in the HT bSDD. This categorization not only aids in identifying different types of robots but also in understanding their unique capabilities and limitations. By doing so, the HT bSDD can facilitate more effective deployment of robotic technology, optimizing tasks ranging from simple material handling to complex construction processes, and ensuring seamless integration into existing construction workflows. This approach represents a significant step towards a more automated and efficient construction industry, where robots play a key role in various stages of building and demolition processes.

Areas (mission plannings): Another group of terms that need to be implemented within the bsDD concerns the ares where different types of activities can be performed. In partucikary 'mission planning area,' in the context of automating area scanning of built assets using UGV. A precise description of these areas with specific and standardised characteristics is essential for accurate representation on the BIMxD platform. Moreover, these descriptions should be versatile enough to be reused in other projects where digital surveys are closely tied to the BIM model. This implementation will facilitate more efficient and precise planning and execution of construction projects, leveraging advanced drone technology for comprehensive area analysis and integration with BIM processes.

Falling Hazards: In the context of the HT bsDD, it's crucial to implement terms that address the risks associated with falling hazards in construction sites. This includes defining areas prone to such hazards, missing part in the construction elements specifying safety protocols, and delineating preventive measures in the BIMxD platform. Accurate and standardized descriptions of these risk zones are essential for ensuring the safety of workers and for facilitating the integration of these safety measures into the BIMxD platform. This effort aims to enhance the planning and execution of construction projects by prioritizing safety, particularly in high-risk environments.

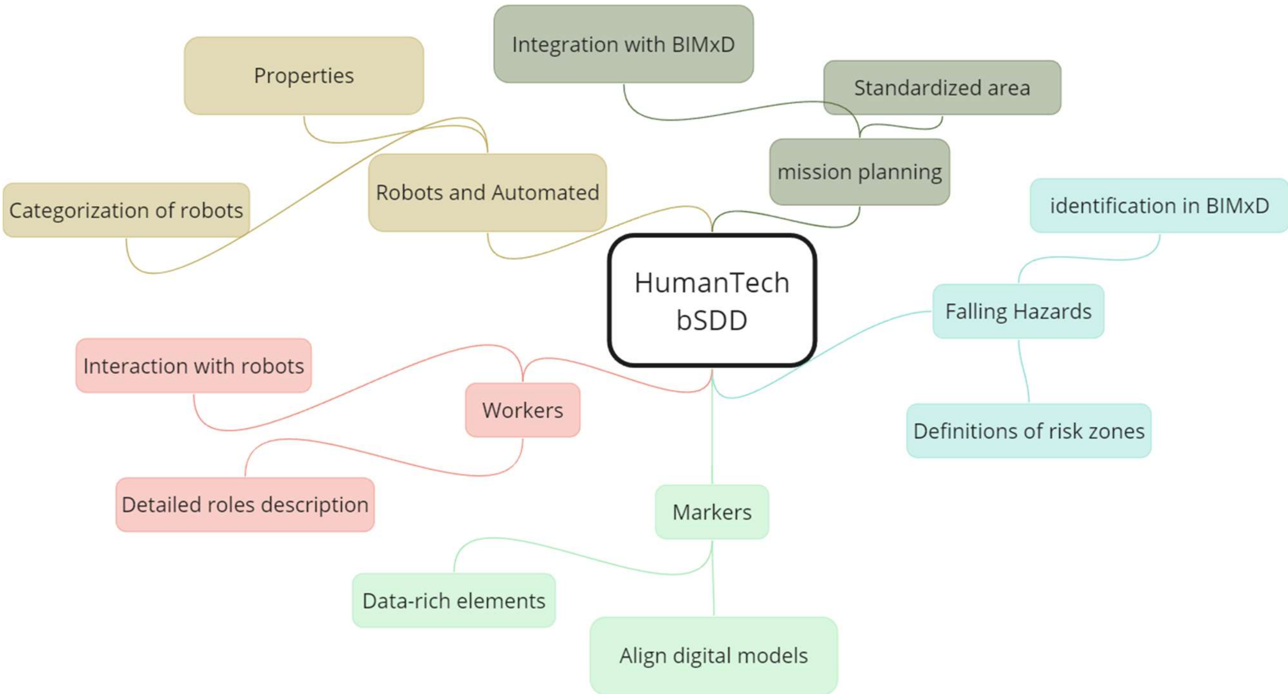

Fig. 1 Schema of the terms that needs to be enriched in the Humant Tech bSDD to expand the IFC schema

5. Conclusion and Next Steps

The ongoing evolution in the construction sector, especially in managing construction and demolition phases, is pivotal for driving efficiency, collaboration, and technological integration. The integration of comprehensive data, particularly regarding robotic elements, into Building Information Modeling (BIM) processes, marks a significant stride in this direction. This integration is crucial for facilitating seamless collaboration between robots and human workers, thus enhancing efficiency and innovation within the BIM framework.

The focus on interoperability and openBIM standards, including the critical analysis and augmentation of these standards, plays an essential role in these advancements. By enabling seamless information exchange across diverse stakeholders and ensuring data longevity throughout an asset's lifecycle, these standards foster a more adaptable and dynamic construction environment. OpenBIM, with its core principles of vendor neutrality, interoperability, and data transparency, is instrumental in breaking down information silos and promoting unified project management approaches.

In the context of Task 2.4 and the upcoming deliverable 2.5, the next steps involve implementing these enhanced openBIM standards, particularly in defining a detailed BuildingSMART Data Dictionary (bsDD) that incorporates the results from the technical work packages. This detailed bsDD will be pivotal in capturing and articulating a comprehensive range of construction elements, processes, and technologies, including the innovative integration of robotic systems. It will serve as a cornerstone for ensuring data consistency, interoperability, and a standardized approach across various construction phases and stakeholders.

Moreover, the definition of Information Delivery Specifications (IDS) will be a key component of this deliverable. IDS will provide a structured and precise mechanism for specifying information exchange requirements, making them computationally interpretable. This specification will ensure that the data exchange aligns with the detailed requirements of the construction processes, thereby enhancing the efficiency and accuracy of project execution.

In conclusion, the implementation of these standards in deliverable 2.5 will represent a significant milestone in the journey towards a more modernized, efficient, and technologically integrated construction industry. The detailed bsDD, in conjunction with the IDS, will pave the way for a more cohesive, advanced, and standardized approach to construction project management, ushering in a new era of innovation and collaboration in the sector.

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