plexos
Lean Project Management

plexos
Lean Project Management

Building Information Modeling (BIM) Basics

Introduction

Building Information Modeling (BIM) is a digital process that involves the creation and management of detailed 3D models of a building that goes beyond the simple visualization, incorporating comprehensive information about building components, such as materials, dimensions, and performance properties.

BIM Basics

BIM Dimensions

BIM dimensions represent varying levels of information complexity within a Building Information Model. 4D integrates time-based data into the 3D model, enabling construction scheduling and simulation. 5D BIM incorporates cost data, facilitating accurate cost estimation, tracking, and control throughout the project lifecycle.

OpenBIM

OpenBIM is a BIM approach that emphasizes the use of open standards to facilitate interoperability, data sharing, and interoperability among different software applications, using open standards like IFC (Industry Foundation Classes),

According to Buildingsmart, OpenBIM facilitates and enhances:

- **Interoperability**: Enabling communication between different software applications thanks to the use of open and neutral standards.
- **Reliable Data Exchanges**: Ensuring integrity, accuracy and data compatibility, avoiding vendor lock-in.
- **Enhanced Collaboration Workflows**: Allowing multidisciplinary teams to work together without being constrained by proprietary formats.
- **Flexibility**: Allowing organizations to choose technologies that best suit their needs.
- **Sustainability**: Ensuring that data remains accessible and usable over time.

IFC format

IFC (Industry Foundation Classes) is a standardized, open file format used in Building Information Modeling (BIM), that offers a structured framework for representing building

and construction data, acting as a common language that allows different software programs to share and exchange building data seamlessly, guaranteeing the Interoperability and collaboration.

IFC tree structure

IFC makes use of a hierarchical schema to organize information into logical entities and relationships. This schema is founded upon three core concepts:

- **IfcObjectDefinition** defining the objects, entities, and elements,
- **IfcRelationship** defining relationships between them, and
- **IfcPropertyDefinition** defining its associated properties.

The Hierarchical Organization is:

- **Project:** The top-level entity, encompassing all elements within a specific construction project.
- **Building:** Represents individual buildings or structures within the project.
- **Building Story:** Divides buildings into distinct levels or floors.
- **IFC Classes:** Represent the fundamental building blocks of the model, defining the core concepts and their attributes. An example is *IfcWall*, which represents the general concept of a wall.
- **IFC Types:** Represent specific instances of a class, providing further details and variations. For example, *IfcWallType* might define specific wall thicknesses, materials, or fire ratings. Essentially, classes provide the framework, while types offer customization and specificity within that framework.
- **IFC Elements:** Represents the specific instances, physical components, of the building, including walls, columns, beams, doors, windows, and more.

In Figure 1 can be seen an IFC tree with a class *IfcWall*, which have two types: *IfcBasicWallMuro* and *IfcWallPantalla*, and three elements for the first type (Highlighted in yellow).

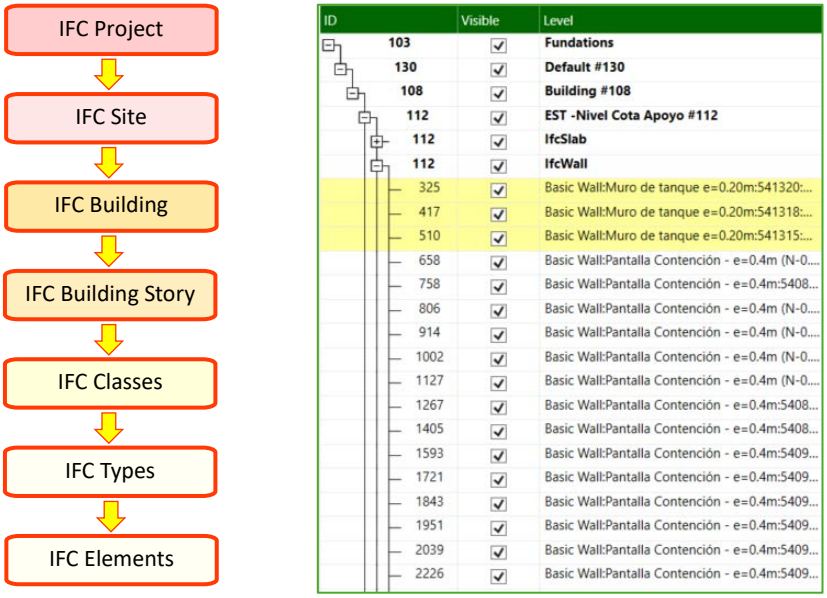

Figure 1 IFC tree structure with Plexos Project

BIM Object, BIM Entity and BIM Element

While the terms object, entity and element are often used interchangeably, there is a subtle but important distinction between them:

- **BIM Object:** This is the most general term, referring to any digital representation of a real-world or conceptual component within a BIM model. It can be anything from a simple geometric shape to a complex assembly of various parts, each with its own properties and behaviors.
- **BIM Entity**: Represents any object or component within a BIM, serving as a framework for organizing and classifying information. This encompasses both physical and non-physical aspects, including tangible elements like walls and doors, as well as abstract entities such as spaces, zones, and grids. Each entity has a set of predefined properties that describe its characteristics and behavior.
- **BIM Element**: Specifically refers to the physical components of a building and used to refer to a particular instance of a BIM object or entity. These are tangible and measurable, possessing defined geometry, material properties, and other quantifiable characteristics. Elements can have specific properties that are unique to that instance, such as their size, color, and location.

In summary, a BIM object is a general term for any digital representation in a BIM model, an entity is a specific type of BIM object defined by the IFC standard, and an element is a particular instance of a BIM object or entity within a specific project.

All BIM elements are BIM entities, but not all BIM entities are BIM elements.

Element Property, Attribute, and Property Sets

BIM properties are data associated with BIM objects. These properties provide essential information about the object, including its function, dimensions, materials, and other relevant characteristics.

BIM attributes are specific pieces of information associated with an object that can be customized to suit the project's needs and can include details like manufacturer, cost, warranty information, or any other relevant data. Attributes provide flexibility in storing and accessing information related to the object.

Property sets are collections of related properties and attributes that are grouped together to organize and manage information about an object. Each property set typically focuses on a specific aspect of the object, such as its common properties, material properties, or performance properties, and quantities. By using property sets, BIM models can store and manage large amounts of data in a structured and efficient manner.

In Figure 2 can be seen the property sets of a BIM element, with its associated properties and attributes in Plexos Project.

Figure 2 Element Properties and Property Sets

Model Federation and integration.

Federation and Integration involve combining models from different disciplines, however, they differ in their approach and level of data sharing:

Federation, as defined in ISO 19650[1], is the process of combining BIM models into a single, unified model, but keeping models as separate Models, where each discipline maintains its own native model. Federated models can be displayed in a combined single view for coordination and clash detection, with limited data exchange. The main advantage is that federated models maintain data ownership and control within each discipline, reducing model complexity, and facilitating collaboration, being recommended by the main international standards (Figure 3 RHS).

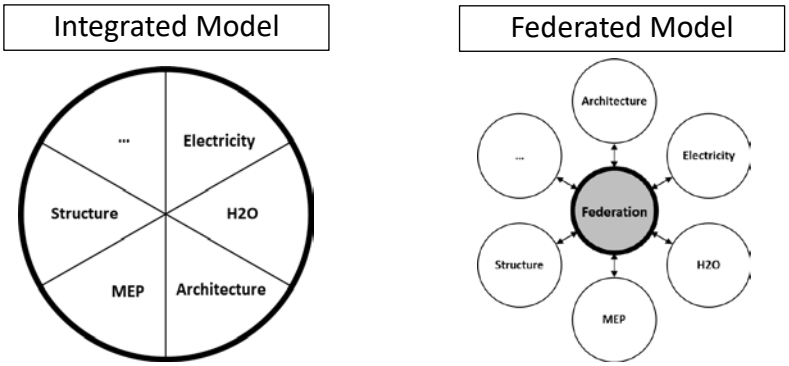

Figure 3 Integrated Model vs Federated Model

An Integrated Model is a single model, where all disciplines work within a single, shared model environment, with full data exchange where parametric and geometric data is shared and synchronized across disciplines, increasing the model complexity, and can be more resource intensive (Figure 3 LHS).

ISO 19650 highly recommends the models federation and the development of a federation strategy to help plan the production of information by separate task teams.

In this line, Plexos Project enables users to manage federation criteria and control the visibility of models within the BIM models manager (Figure 4). Visibility is managed through checkboxes associated with each branch of the IFC tree. Unchecking a node will automatically hide all dependent objects.

[1] ISO 19650 is an international standard that provides a framework for managing information throughout the lifecycle of a built asset using Building Information Modeling (BIM). It establishes principles and requirements for collaboration, data exchange, and asset handover to ensure the effective use of information across all project phases.

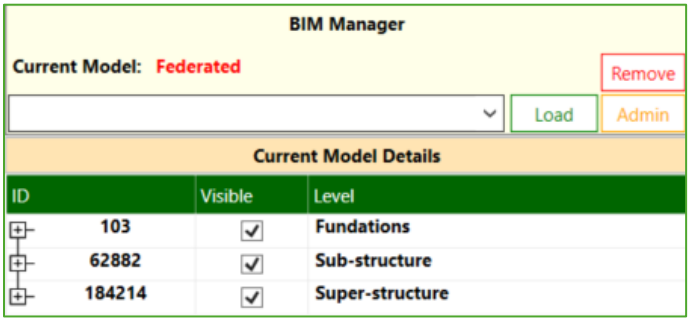

Figure 4 BIM Models manager

Furthermore, users can administer certain IFC model properties, including the file path, link type (linked or embedded), and federation integration (Figure 5). By default, all models are integrated into the federation, and the link type is set to 'linked' to minimize file size.

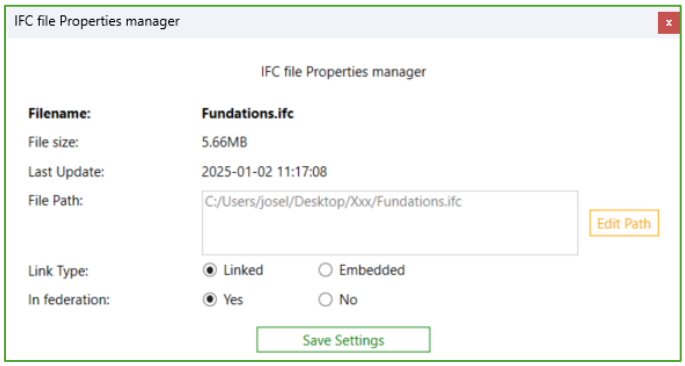

Figure 5 Model manager dialog

The linked IFC file mode within Plexos is particularly advantageous when collaborating with a CDE environment. This integration ensures that Plexos models are consistently updated with the most recent versions of the IFC files, streamlining the design and construction process.

Information Management

According to ISO 19650, **Information Management** is the systematic approach to managing information throughout the entire lifecycle of a built asset, from conception to demolition. It encompasses the processes, tools, and techniques used to create, capture, store, retrieve, use, and dispose of information in a way that supports effective decision-making, collaboration, and asset performance.

Assembly-Code and Classification system

The Assembly-Code[2] is a identifier used in the AEC industry to organize and categorize building elements within a standard classification system. It's a hierarchical system that helps in managing information, improving coordination, and facilitating communication among project stakeholders working with Building Information Modeling (BIM).

The classification system for each element can be found in the [Classifications] tab on the BIM models manager Panel (Figure 6).

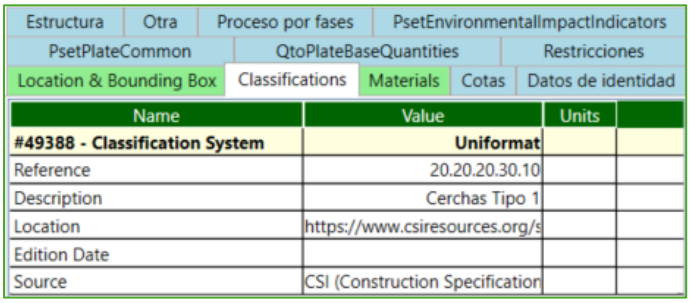

Figure 6 [Classifications] tab

The Assembly-Code is the most important property for information management and structuring data, indexing durations, resources, unit prices, quantities and technical specifications, being the most common: MasterFormat, UniFormat, and OmniClass. Each Classification system offers distinct advantages, and suitability, depending on the specific project needs:

Uniformat.

The Uniformat classification system is a widely used standard in the construction industry, particularly in the United States and Canada. It provides a hierarchical framework for organizing building components and systems, facilitating consistent communication, cost estimation, and project management. The system categorizes elements into levels, with Level 1 being the broadest and Level 4 offering the most details.

The level 1 categories are:

[2] View the whitepaper Information Structure for further information about how to manage assembly codes and classification systems.

- A SUBSTRUCTURE
- B SHELL
- C INTERIORS
- D SERVICES
- E EQUIPMENT AND FURNISHINGS
- F SPECIAL CONSTRUCTION AND DEMOLITION
- G BUILDING SITEWORK
- Z GENERAL

OmniClass

"*OmniClass is a comprehensive classification system for the construction industry, encompassing key elements of both MasterFormat® and UniFormat® for building lifecycle and project management*. " (CSI Construction Specifications Institute, s.f.).

OmniClass comprises 15 tables, each dedicated to a distinct aspect of construction information. These tables can be used independently to categorize specific information types or combined to classify more complex subjects.

The foundation of OmniClass lies in the principle of segregating information into discrete, coordinated tables. Each table focuses on a particular facet or perspective of the built environment, organizing information within its specific domain.

OmniClass provides a comprehensive classification system for the built environment, encompassing 15 interrelated tables that cover various aspects of construction. These tables are:

Construction Entities:

- By Function (Table 11): Units of the built environment characterized by their primary purpose.
- By Form (Table 12): Units of the built environment characterized by their physical shape or configuration.

Spaces:

- By Function (Table 13): Basic units of the built environment defined by physical or abstract boundaries and characterized by their intended use.

- By Form (Table 14): Basic units of the built environment defined by physical or abstract boundaries and characterized by their physical shape.

Elements:

- Elements (Table 21): Major components of a construction entity that fulfill essential functions. Table 21 incorporates components of Uniformat.
- Designed Elements: Elements for which specific design requirements have been defined.

Work Results (Table 22):

Construction outcomes achieved during specific stages of the project, identified by factors such as the trade involved, resources utilized, and the resulting part of the construction entity. Table 22 incorporates components of MasterFormat.

Products (Table 23):

Components or assemblies of components intended for permanent incorporation into construction entities.

Project Phases (Table 31):

- Stages: Major segments of a project.
- Phases: Subdivisions within each Stage, representing specific work portions.

Services (Table 32):

Activities, processes, and procedures related to the entire lifecycle of a construction entity.

Disciplines (Table 33):

Practice areas and specialties of professionals involved in the construction process.

Organizational Roles (Table 34):

Functional positions that are held by individuals or groups participating in the construction process.

Tools (Table 35):

Resources used in the design and construction process that are not part of the finished building.

Information (Table 36):

Data referenced and utilized throughout the construction process.

Materials (Table 41):

Substances used in construction, including raw materials and refined compounds.

Properties (Table 49):

Measurable or definable characteristics of construction entities.

MasterFormat

MasterFormat is a hierarchical classification system for construction that employs an enumerative structure, organizing information into "sections" defined by unique numbers and titles.

The primary organizational units are "divisions," representing broad categories of construction products and activities. Each division is further subdivided into increasingly specific levels (two, three, and often four), allowing for detailed categorization and precise information retrieval.

Differences

Uniformat, Omniclass, and MasterFormat are all classification systems used in the construction industry, each with its own unique structure and purpose.

While Uniformat focuses on building systems, Omniclass offers a broader perspective, integrating elements of both MasterFormat and Uniformat. MasterFormat, on the other hand, is specifically designed for organizing construction specifications. The choice of classification system depends on the specific needs and goals of the project.

Level of Information (*LoI*) and Level of Development (*LOD*).

LOD is usually a misunderstood term, sometimes referred to Level of Detail rather than Level of Development, with terminological differences depending on the international context.

According to BIM Forum[3], Level of Information Need (*LoI*) and Level of Development (*LOD*) are complementary and not interchangeable concepts[4]:

- **Level of Information Need**: Specifies the quality, quantity, and granularity of geometric, alphanumeric, and documentation information to be included in information deliverable (ISO 7817-1:2024). *LOI* identifies the specific information required, who needs it, and when it's needed. This ensures that all the information collected serves a clear purpose and contributes effectively to the project's progression.
- **Level of Development:** Defines the detail, dimensionality, location, appearance, author, and date of geometric information within the larger framework of Level of Information Need.

LOD Requirements are Cumulative and progress from conceptual (LOD 100) to as-built (LOD 500). LOD 100 represents basic shapes and locations, while LOD 500 includes precise dimensions.

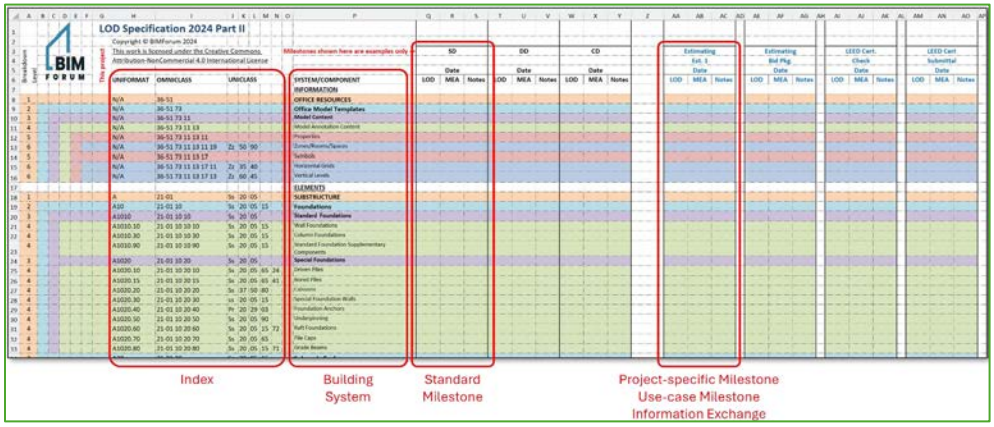

Figure 7 LOD Model Element Table by BIM Forum

LOD is not a fixed project specification. Instead, it's determined for each delivery based on the specific project phase and its requirements. BIM Forum provides a cross-reference table (Figure 7) mapping Uniclass, Omniclass and Uniformat classification Systems. This resource

[3] The BIM Forum is a non-profit organization focused on advancing the use of Building Information Modeling (BIM) in the construction industry (https://bimforum.org/).
[4] Level of Development (LOD) Specification. Level of Development (LOD) Specification – BIM Forum

facilitates concise definition of geometric models at the element level by incorporating Level of Development (LOD), element author, and creation date.

The Information requirements (IRs).

ISO 19650 recognizes four primary types of information requirements within the context of building and civil engineering projects (Figure 8 LHS):

1. **Organizational Information Requirements (OIRs)**: These high-level requirements outline an organization's overall approach to information management. They encompass policies, procedures, standards, and templates that guide how information is handled throughout the asset lifecycle.
2. **Asset Information Requirements (AIRs)**: These requirements focus on the specific information needed to manage and operate a built asset effectively. They consider factors like maintenance, repairs, upgrades, and eventual decommissioning.
3. **Project Information Requirements (PIRs)**: These requirements are tailored to the specific needs of a particular project. They address the project's scope, objectives, stakeholders, and the information necessary to achieve successful delivery.
4. **Exchange Information Requirements (EIRs)**: These requirements govern the exchange of information between different parties involved in the project. They specify the format, level of detail, and timing for information sharing to ensure seamless collaboration and avoid duplication of effort.

The information deliverables

Asset information model (AIM)

The asset information model (*AIM*) enables efficient strategic and day-to-day asset management processes by facilitating data sharing and collaboration within a CDE.

Project information model (PIM)

he Project Information Model (*PIM*) supports project delivery and contributes to the Asset Information Model (*AIM*) by enabling asset management activities during the operational phase. The *PIM* is managed within a *CDE* (Figure 8 RHS).

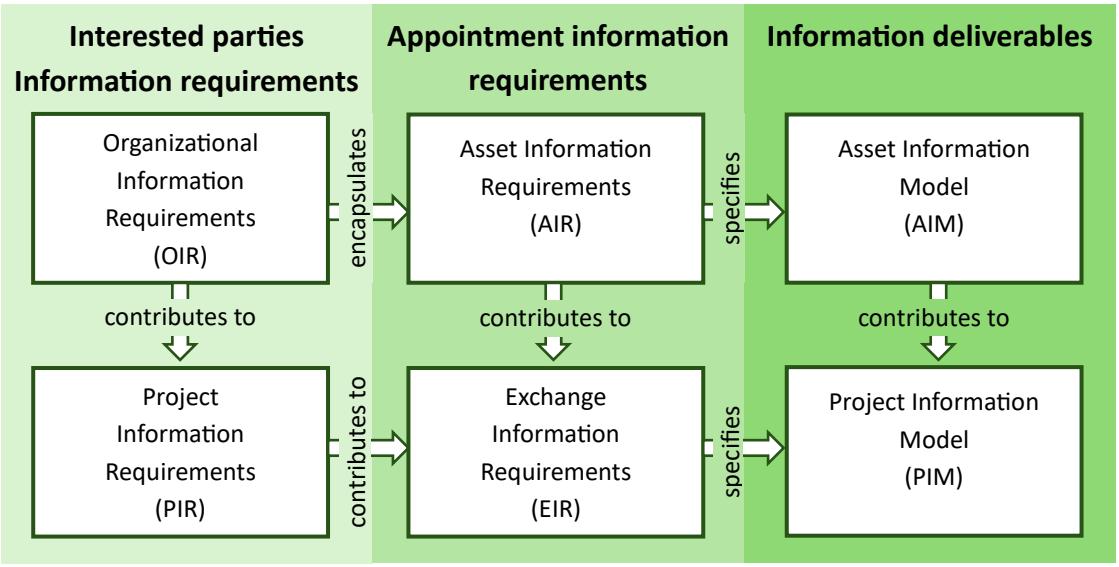

Figure 8 ISO 19650 Information requirements (Adapted from ISO 19650-1)

Collaboration

The Common Data Environment.

According to ISO 19650, a ***Common Data Environment* (*CDE*)** is an Agreed source of information for any given project or asset, for collecting, managing and disseminating each information container through a managed process

The *CDE* is the **single source of information** used to **collect**, **manage** and **disseminate** documentation, the **graphical model and non-graphical data** for the whole project team.

Creating this single source of information facilitates collaboration between project team members, enabling them to access and exchange data in real-time, and helps avoid duplication and mistakes, enhancing overall project efficiency and quality.

Plexos Project leverages BIMserver.center[5], a Common Data Environment (CDE) developed by Cype Software (Figure 9, left). However, Plexos Project offers flexibility by allowing you to work with any CDE, as long as you know the specific local file path.

[5] BIMserver.center

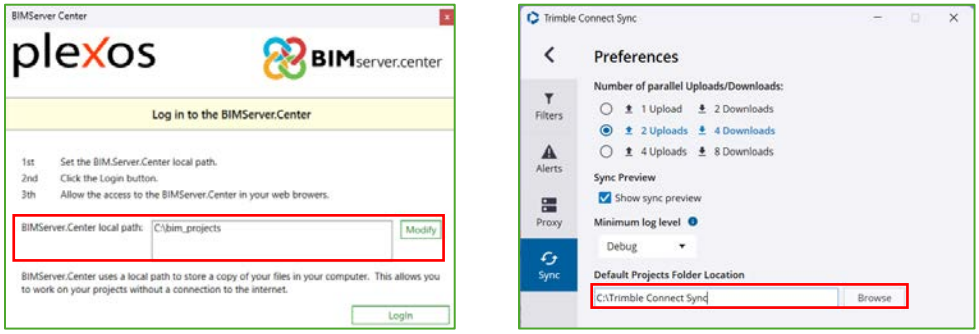

Figure 9 Setting the BIMserver.center and Trimble Connect CDEs

For optimal performance and to ensure proper updates, we strongly recommend setting a custom local path for your CDE (e.g., C:\desired_path\user_email) instead of relying on the default location (C:\Users\Documents\...) (Figure 9, right).

The process for connecting to the BIMserver.center is:

1. Click on the [BIMserver Manager] button (Figure 10).

Figure 10 Access to the BIMserver.center

2. Login if necessary (Figure 11).

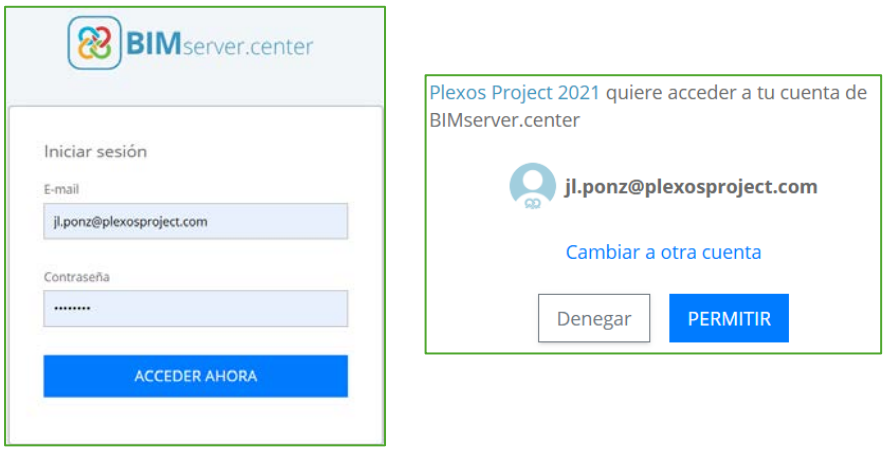

Figure 11 Log in to BIMserver.center

3. Close the web browser when the message in Figure 12 appears.

Figure 12 Log in successful

4. Continue to access the BIMserver.center and select the project (Figure 13).

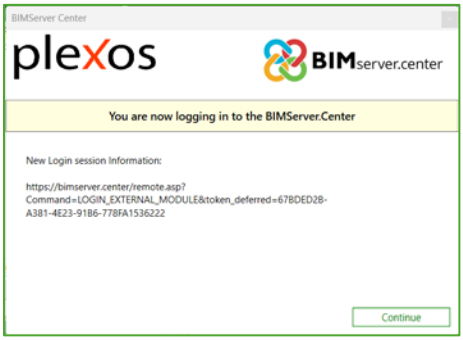

Figure 13 Continue to access the BIMserver.center

5. Select the project. If the desired project is not visible in the grid, increase the number of projects displayed. Additionally, you can sort projects by ID, Name, creation date, or last change date in either ascending or descending order (Figure 14).

Figure 14 Select the project

6. Select the contribution (Figure 15).

Figure 15 Select the contribution

7. Select the IFC model (Figure 16).

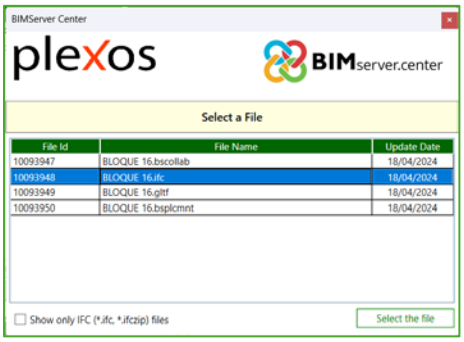

Figure 16 Select the IFC model

For connecting to a CDE different to BIMserver.center load the models directly from the local path used by the CDE.

The CDE Information Workflow.

The CDE information workflow in ISO 19650 refers to the state of information within the Common Data Environment, by four key stages (Figure 17):

- **Work In Progress (WIP)**: Information is being created or modified, not yet ready for sharing.
- **Shared**: Information is shared within the project team for review and coordination.
- **Published**: Information is finalized and approved for use in decision-making or construction.
- **Archived**: Information is no longer actively used but retained for historical or legal purposes.

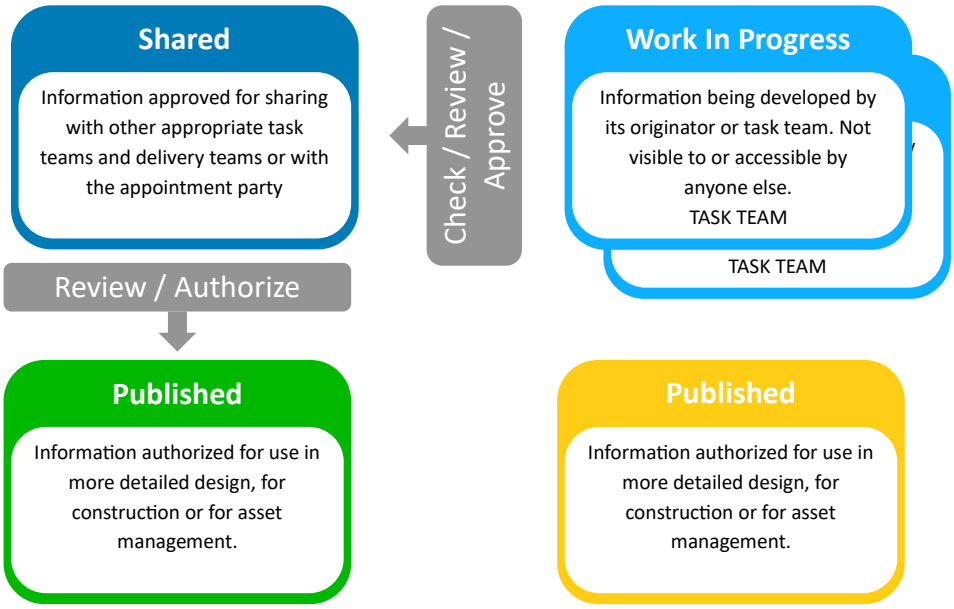

Figure 17 CDE workflow (Adapted from ISO 19650-1)

The BIM Collaboration Format (BCF).

The BIM Collaboration Format (BCF) is an open standard developed by BuildingSMART[6] International to facilitate communication and issue resolution within BIM projects. It's essentially a structured file format designed to capture and share information about issues related to a BIM model (Figure 18).

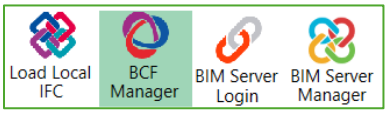

Figure 18 Acces to the BCF manager

The key components of BCF are:

- **Issues:** Anything from design conflicts to coordination problems. Located on the LHS of the BCF manager (Figure 19).
- **Comments and replies to comments:** Discussions of issues by the users. Located on the RHS of the BCF manager (Figure 19).

[6] Buildingsmart is an international organization which aims to improve the exchange of information between software applications used in the construction industry. https://www.buildingsmart.org/

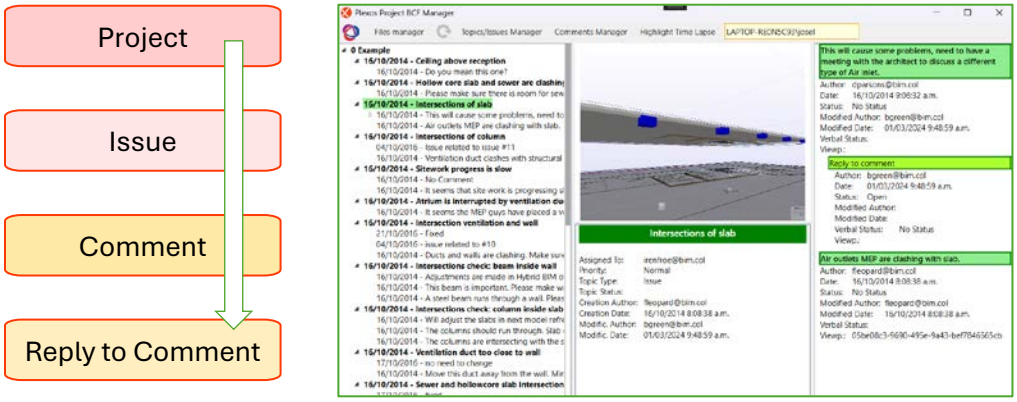

Figure 19 BCF manager

To ensure data integrity and accuracy, **all issues and comments added to the BCF are automatically saved and cannot be deleted**. However, **authors can modify existing entries being recommended to change just the status and avoid altering the original issue**.

To enhance effective collaboration, Plexos incorporates an alert in the top menu. This alert checks the integrity of the information every 30 seconds. If any changes are detected, the alert icon will turn red, indicating a potential data discrepancy recommending reloading the BCF file (Figure 20).

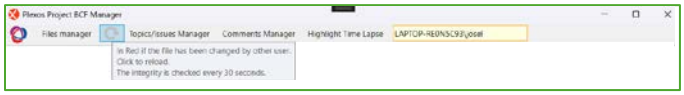

Figure 20 Alert for Reloading

Adding an Issue:

To add or edit an issue, click on the menu button or right-click (context menu) and select the desired option (Figure 21), and the dialog of Figure 22 will appear.

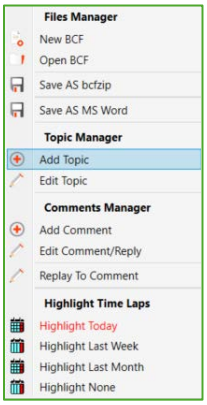

Figure 21 BCF Context menu

The available fields for an issue are (Figure 22):

- **Title** (Mandatory): Title of the topic.
- **File** (Mandatory): The BIM file related to this topic.
- **Assigned To** (Mandatory): The user to whom this topic is assigned to. The combo box for user selection is auto populated based on the project data, but new users can be added as needed.
- **Priority** (Mandatory): Topic priority. The predefined priorities are: *Highest*, *Critical*, *High*, *Medium*, *Low*, and *Lowest*. As previously, this combo box is auto populated, but new priorities can be added as needed.
- **Type** (Mandatory): Type of topic. The predefined types are: *Undefined*, *Comment*, *Issue*, *Request*, *Fault*, *Inquiry*, *Solution*, *Remark*, *Clash*, *Commissioning*, *Coordination*, *Design*, *Assembly Code*, *Quantity Property*. As previously, this combo box is auto populated, but new types can be added as needed.
- **Status** (Mandatory): Status of the Issue. The predefined status modes are: *New*, *Open*, *Closed*, *Done*, *In Progress*, *Doing*, *Waiting*, *Completed*, *Needs Review*, *Not Approved*. As previously, this combo box is auto populated, but new status can be added as needed.
- **Description** (Mandatory): Description of the topic.
- **Creation Author** (Automatic): The user who initiated the topic. By default, it reflects the current Windows user identity. You can manually edit this field in the text box located in the upper right corner of the BCF window
- **Creation Date** (Automatic): Date when the topic was created.
- **Modified Author** (Automatic): User who modified the topic (when it was commented or replied).
- **Modified Date** (Automatic): Date when the topic was last modified (when it was commented or replied).
- **Link Reference** (Optional): Path for further information about the issue.
- **Documents** (Optional): Documents related to the issue
- **Details** (Optional): additional information about the issue.
- **Snapshots** (Optional): Images to illustrate the issue.

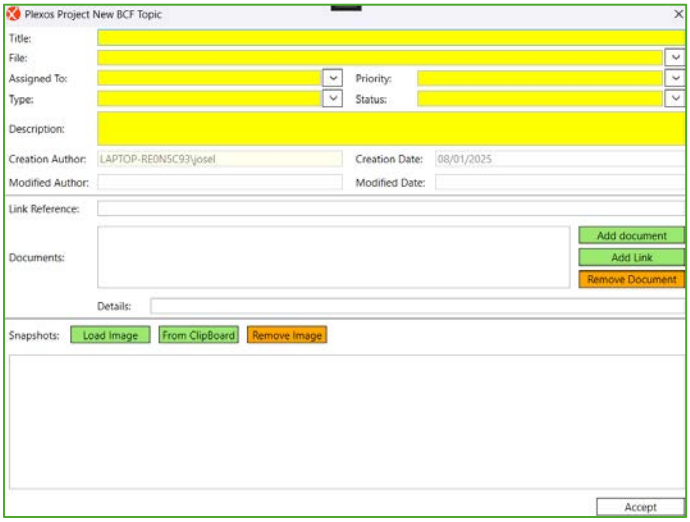

Figure 22 Adding/Editing an Issue

Commenting or replying to a comment

The available fields for commenting on an issue, or replying to an existing comment are (Figure 23):

- **Comment** (Mandatory): Text of the comment.
- **Author** (Automatic): Author of the comment (as previously).
- **Creation Date** (Automatic): Date when the comment was created.
- **Modified Author** (Automatic): User who replied to the comment.
- **Modified Date** (Automatic): Date when the comment was replied.
- **Status** (Mandatory): Status of the Comment or reply to Comment.
- **Verbal Status** (Mandatory): Informal Status of the comment.

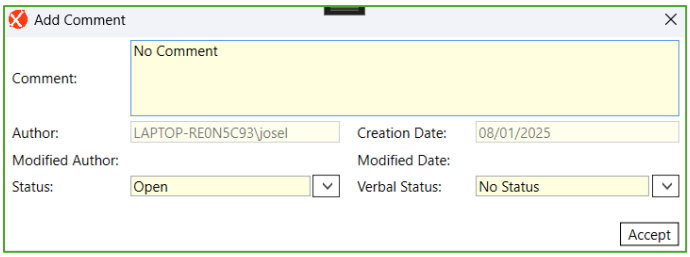

Figure 23 Commenting or replying to a comment