

## DIGITAL TWIN 3D PLATFORM FOR COLLABORATIVE REPRESENTATION AND EDITING OF IFC DOCUMENTS APPLIED TO THE BIM METHODOLOGY

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### ABSTRACT:

Currently, the Architecture, Engineering, Construction (AEC) sector lacks tools for digitization, being forced to resort to proprietary software and closed file formats with complex and highly expensive licensing models. Thus, new opportunities arise for the creation of tools, resources and knowledge that promote the renewal and impetus of the entire sector. Most of the sector's R&D activities are not only directed to the development of digital tools, but also to develop and provide the methodological bases of standardization, organization, and management of information necessary for the implementation of the BIM and Digital Twin methodology in Portugal, applied to the construction and asset management of buildings and infrastructures. In the present work, the described solution is a cross-platform web application that has all base requirements of a standard BIM platform, plus georeferencing of IFC documents using orthophoto maps and free access to base cartography available globally. All components of the solution were developed using open source technologies and universal free access. The contributions of this work will also serve to improve the set of tools and solutions available to the community. The developed platform will be available openly to all companies that want to engage in the BIM community and ought to actively participate in and foster the development, improvement, and promotion of this platform within the AEC sector.

### 1. INTRODUCTION

Currently, in the construction industry, where multiple organizations actively collaborate on complex projects in the most diverse activities (studies and topographic surveys, project conception and design, definition of specialties, monitoring of execution, etc.), the existence of compatible tools and assets between all those involved in the project, in the most varied stages of its execution, is essential for the synchronization of the work and the expectations of the teams, and is therefore vital to guarantee the success and fulfillment of the established deadlines (Laakso and Kiviniemi, 2012).

According to Laakso and Kiviniemi, there is a need for technical platforms based on open standards that allow communication and collaboration between organizations without the need to acquire proprietary software (Laakso and Kiviniemi, 2012). Organizations in the AEC industry, in conventional practice, continue to use 2-Dimensional (2D) information which can result in communication problems between the parties involved. These problems cause obstacles in the construction process, delays, uncontrolled increases in expenses, poorly executed work, and even design conflicts. To solve this problem, the BIM (Building Information Modeling) methodology was introduced in construction projects effectively and efficiently through computerization and integrated information management systems (Latiffi et al., 2014).

Thus, BIM presents itself as a common model for a set of information related to construction, being the basis for communication between different domains and support of the construction life cycle, allowing interoperability through the use of standards, connecting projects, participants and systems.

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To promote the adoption of BIM in Portugal, the Architecture, Engineering and Construction (AEC) cluster in Portugal emerges as a platform that aggregates knowledge and competence in the construction sector, which aims to promote business competitiveness through research activities. The AEC sector is characterized by its high levels of competence, being able to respond to the rigor and demands of international standards imposed by the great world leaders of the industry. This sector represents 2.2% of Portugal's national GDP (Gross Domestic Product) (AICCOPN and AECOPS, 2021) and aims to increase exports and qualified employment, promote international visibility, strengthen skills, and promote the creation of partnerships and cooperation. It is of central importance in the national economy, being responsible for 350 thousand jobs, 19.9 billion euros in turnover and 4.5 billion euros in exports (IAP-MEI Agência para a Competitividade e Inovação, 2021).

In an attempt to standardize the format for exchanging scanned documents in BIM, the IFC (Industry Foundation Classes) proposal appears. IFC is an open file format and an international standard (ISO 16739-1:2018) based on the EXPRESS (ISO, 2018) language, created for the construction industry and developed by the Industry Alliance for Interoperability (IAI) in 1994 (Hagedorn and Döllner, 2007), with the vision "To enable software interoperability in the AEC/FM industry". It is a data structure that enables the exchange of information between different BIM platforms (Xu et al., 2020), widely used by the AEC and Facility Management (FM) industry, including definitions that cover the necessary data for the life cycle of buildings.

This initiative began with the creation of a consortium for the construction industry formed by Autodesk (at the time it was already the world's largest CAD software company for Engineering/Architecture) and eleven more American companies,

such as AT&T, HOK Architects, and Honeywell. In 1997, users of Autodesk products insisted that the IFC format should be non-proprietary, provoking a reconstitution of the organization, renaming itself the International Alliance for Interoperability, and becoming an industry-led non-profit organization promoting the IFC format as a neutral product model for infrastructure lifecycle support (Eastman and Eastman, 2008). Currently, the organization that develops and maintains the IFC format is buildingSMART International, renamed in 2005 from IAI. Since the creation of the IFC standard, several versions have been released (IFC1.5.1, IFC2.0, IFC2x, IFC2x2, IFC2x3, IFC4, IFC4 Add2), the most used being IFC2x3 (Bimspot, 2021) and currently planning the release of the IFC5 version (Inovation, 2021). Thus, IFC is currently supporting a large number of applications and systems from buildingSMART International certified organizations (Majcher, 2019).

With the investment made by the AEC sector for the digital transformation of the sector, a new concept appears, the Digital Twin. The Digital Twin concept presents itself as the digital representation of a physical asset, or digital twin, which improves existing processes through cost reduction, greater accessibility, and increased operational efficiency (Mehra, 2022). Digital Twin provides real-time fundamental insights into performance and activity underway.

The basis of a digital twin can consist of the information resulting from a BIM process, being essentially the living version of the project, allowing the data to evolve and transform in real-time. To obtain the best value from each asset at each stage of a construction project, the use of a digital twin contributes to the improvement of project life cycles.

This work aims to present a collaborative Digital Twin 3D platform for handling IFC documents using only Web browsers, in an innovative, agile way capable of rivaling the big players in the market. This solution, fully developed using open source technologies, will enable the business fabric of the AEC sector for interactive and real-time collaboration in BIM/IFC projects.

The remainder of this paper is composed as follows: Problem definition, Observations and State of the Art, Solution, Case Study, Conclusions and Future Work, and Acknowledgements.

## 2. PROBLEM DEFINITION

In the current scenario, the Architecture, Engineering and Construction (AEC) cluster in Portugal lacks products, processes, and services that enhance collaboration, training, and innovation in the sector, to compete in the global market. Dependence on proprietary tools for designing AEC projects, using closed file formats and with complex and expensive licensing models, reveals an opportunity for new tools that can interact collaboratively based on driven standards by the AEC community itself. Thus, with the emergence of the IFC interoperable format for the BIM methodology, it is necessary to develop open and universally accessible tools, capable of representing and editing, in a collaborative, interactive and real-time way, 3D BIM models following international standards and specifications. These market opportunities, associated with the digital transition of the AEC sector, attract numerous stakeholders to this new reality, triggering a set of initiatives that foster competitiveness. However, the approach to these problems remains faithful to a matrix of classic solutions in this sector, in which the offer of products is based on highly specialized desktop software, and

whose use of the IFC standards is limited only to guaranteeing interoperability with other systems, by exporting and importing IFC files and not directly handling them. In this way, opportunities are created for companies that wish to develop IFC file handling capabilities, through universal access Web tools that allow them to respond to the requirements and needs of the AEC sector. What currently makes it difficult to create these web applications, in addition to the problems mentioned above, is the complexity associated with reading and writing IFC files and performance problems in web applications, mainly caused by poor memory management related to reading/writing files of large dimension. Therefore, it is intended to develop a product that can respond to these needs through the development of a 3D Digital Twin platform for the collaborative representation and editing of Industry Foundation Classes (IFC) documents, a standard format with the digital description of construction industry assets, applied to the BIM methodology. This work is part of a development component within the scope of a mobilizing project, called REV@CONSTRUCTION, in which the company 3Maps is a partner. REV@CONSTRUCTION is a project funded by Portugal 2020 that aims to develop solutions for the digital transformation of companies in the Architecture, Engineering and Construction (AEC) sector, intending to promote their competitiveness and sustainable growth, as well as a strategic alignment with the sector at European level. The component to be developed is based on the concept of Digital Twin in construction, with 3D digital models, permanently updated, and increased with information, which allows the knowledge of the reality of the work in the back-office, in real-time, and facilitates the taking of decision, including the constant adjustment of resource allocation and development of production processes under optimal conditions and the overlap of the virtual domain with the physical domain.

## 3. OBSERVATIONS AND STATE OF THE ART

In the construction industry, where multiple organizations collaborate on complex projects in the most diverse activities, the existence of compatible tools and assets in the various phases of project execution is vital. As a conventional and recurring practice, companies continue to apply technology-supported only in 2-Dimensions (2D) in their projects, which results in communication problems between the parties involved and difficulties in the perception and mitigation of errors when synchronizing work. These problems lead to complications in the construction process, delays, increased expenses, poorly done work, and even design conflicts. The BIM methodology was introduced in construction projects to solve this problem effectively and efficiently through computerization and the use of integrated information management systems (Latiffi et al., 2014). BIM is a common model for a set of building-related information, being the basis for cross-domain communication and building lifecycle support, enabling interoperability between different domains, participants, and systems. There are currently four different levels of collaboration on a project, known as BIM maturity levels: levels 0, 1, 2, and 3. As the maturity level value increases, the greater the collaboration in a non-interoperable information sharing project such as Computer-Aided Design (CAD) (Level 0) for information integration in cloud-based environments (Level 3), where it is possible to share models with all project collaborators, allowing the addition or modification of information without losses (Biblus, 2022). In addition to the BIM maturity levels, there are also BIM dimensions that provide a better understanding of the construction design and

the process of linking additional information to building models. There are the following dimensions: 1D - Creation of information, 2D - CAD drawings, 3D - 3D representation of models, 4D - Scheduling, 5D - Cost Estimation, 6D - Sustainability, and 7D - Project management optimization (Ocean, 2022). The BIM concept began to be developed in 1962 by Douglas Engelbart, in an article published “*Augmenting Human Intellect*”, where he describes the transformation of a series of specifications and data input into a review of a structure, having been the main factor for the development of the methodology BIM (Borges, 2018). The appearance of works such as the Building Description System by Professor Charles Eastman of the Faculty of Architecture at the Georgia Institute of Technology criticizes the use of drawings as the only way to construct the communication of information. Caused by the inefficiency and excessive time used to keep the sketches consistent, whenever changes occurred, and by the extreme tendency of errors to happen in the analysis of numerical information taken from the drawings manually (Eastman et al., 1974), Eastman developed the 1970s Building Description System (BDS). This concept involved a library of elements that could be added to a model and a database that allowed the user to find information about the attributes of the elements, such as the type of material and the supplier (Latiffi et al., 2015). BDS was not commercialized and was mainly an experiment, leading Eastman to develop a new project, the Graphical Language for Interactive Design (GLIDE), which had similar characteristics to the BIM methodology currently used (Ter Maaten, 2015). One of the first implementations of this concept was in 1982 with the development of ArchiCAD software, having been boosted in the 2000s with the development of Revit software by Autodesk (Gomes, 2015). Currently, the BIM methodology is the basis of the digital transformation in the AEC industry and has experienced exponential growth related to technological advances and the benefits it brings to the AEC industry. This growth has brought new BIM tools developed by several companies, which, although they share the same goals, have taken different approaches in the design of solutions (Pinto, 2016). In this way, when choosing the software to carry out a project, it is necessary to analyze and evaluate which one is best suited for your development. In carrying out a multidisciplinary project, different software is used, taking into account the various existing specialties, which may compromise interoperability and information sharing by project stakeholders, that is, the ability of two or more systems to exchange information and use correctly the same information in your models. In order to ensure the connection between this different software and to give continuity to the BIM methodology, a free format was proposed that promotes interoperability, the IFC standard. In recent years, the AEC sector has been focusing on digitalization, which is an important evolution for the growth of several developing countries that do not have adequate infrastructure that can keep up with the increase in their population and for the restructuring and repair of older infrastructures in more developed countries. The sector was valued in 2020 at 7.2 trillion US dollars and is projected to reach 15.8 trillion US dollars in 2028. Business volumes benefit by generating competitiveness between organizations, with the development of new concepts and the creation of multiple BIM platforms. In the following subsections, the functionalities and capabilities of the existing BIM platforms and tools on the market that are closest to the proposed solution and that support buildingSMART International standards will be presented. The worldwide reference platform Autodesk Revit will also be introduced for comparison purposes.

### 3.1 Autodesk

Autodesk, Inc. Founded in 1982 by a programmer and entrepreneur named John Walker, is the largest CAD software company globally. John Walker had purchased CAD software, better known as AutoCAD, from creator Michael Riddle for US\$10 million in royalties. With the launch of AutoCAD software on the market and the evolution of technology, Autodesk experienced enormous and rapid success, controlling about 60% of the CAD software market, achieving a sales value of 117 million US dollars at the end of the 80s. It is currently headquartered in Sausalito, California, and has a wide range of products available in over 85 countries, translated into 18 languages (IDCH, 2016).

**3.1.1 Revit** Revit is a BIM modeling software to support engineering projects in relation to the design, construction, and maintenance phases, developed by Revit Technology Corporation in the year 2000. In 2002 Autodesk acquired the company Revit Technology Corporation for 133 million US dollars, adding Revit to the existing family of Autodesk products. Due to its enormous success and professional demands, the software is updated annually, multiplying its tools and properties, and is currently divided into three main branches: Revit Architecture, Revit MEP, and Revit Structure. Autodesk Revit supports collaborative work in multidisciplinary projects and allows the visualization of 2D and 3D digital models and the parameterization of elements in the model in order to enhance the quality and efficiency of the project. The information that can be found in the elements of the loaded models corresponds to their relationships and properties, such as materials, type, and geometry. It is currently the most used BIM modeling software worldwide, with a 46% market share (UNIFY, 2022).

**3.1.2 Viewer** Autodesk Viewer is a Web App to support the development of collaborative engineering projects. It lets you upload, view, analyze and share 2D and 3D models for free, including AutoCAD DWG, DXF, Revit RVT, Inventor IPT, STEP, SolidWorks, and CATIA files formats. As a platform focused on collaboration and sharing of views and drawings of engineering projects, its main features are:

- Visualization modes:
  - Views- Allows you to view the model from multiple loaded views.
  - Model Browser - Allows you to view the various constituent parts of the model individually, for example walls, floors and furniture.
- Element Properties: Allows you to view the properties of elements that contain information such as their dimensions, the material and the layer to which it belongs.
- Exploding/Deconstructing the model: It consists of separating the elements that make up the model in order to be able to analyze the elements individually. There are several levels of model deconstruction that can be changed using a slidebar.
- Make Measurements: Allows you to measure the distance between two points, length or width of a wall, or calculate an angle between three points, obtain the slope of a wall with the floor.
- Navigation Modes:
  - Views- Allows you to view the model from multiple loaded views.

- Using buttons - Allows you to return to the initial view, center the model in the scene, navigate in first person, zoom, rotate, orbit and rotate/slide around the model.
- ViewCube - Allows orbiting around the model according to the chosen axis.
- Comments and Annotations: Allows you to place annotations and comments on the feedback of changes made for other project collaborators to see.

### 3.2 BIMvision

BIMvision is an open-source desktop application that allows viewing BIM models in IFC format in versions 2x3 and 4.0 from CAD systems such as Revit, Archicad, BricsCAD BIM, and Advance without the need to purchase commercial licenses for these systems. BIMvision was developed by Datacomp, a member of buildingSMART Poland, which has been implementing openBIM standards. This software allows construction project collaborators to identify and solve problems in the design phase, such as the efficient circulation of information between the various participants. The main features that stand out are the following:

- Visualization Modes:
  - 3D - Perspective, Orthogonal or Oblique view of the model.
  - Projections in Space - Allows you to project one or all of the planes of the model into space.
  - 2D - Allows you to view the model in two dimensions in a top view.
- Model structure: Allows you to see the structure that makes up the model, the structural tree, which can be organized by types, groups, layers and classifications.
- Actions with elements: Allows you to hide, highlight/highlight, isolate and view their properties.
- Measurements: Allows you to calculate the volume, weight, area, length of the model and the model's constituent elements, count the number of elements of specific types such as doors, windows and walls.
- IFC coordinate synchronization: Allows you to calculate the deviation caused by errors, such as loading multiple IFC models with different coordinate systems, and shift them to the correct position.

BIMvision has some features that do not exist in the free version of the Desktop application, requiring the purchase of proprietary plugins. Some premium features that stand out are as follows:

- Compare IFC files: Allows you to compare any pair of elements in a model and analyze the differences between the respective revisions.
- Collision detection: It allows to detect existing collisions between elements of one or several models.
- Merging IFC files: Allows you to export elements from several loaded IFC files into a single IFC file.

### 3.3 EveBIM

EveBIM is the result of more than 25 years of collaborative research on a European scale. Developed with the largest public and private players in French construction and planning, it

has been proposing new perspectives in the development and renovation of cities and their infrastructure, neighborhoods, and buildings. It is a reference to the Center Scientifique et Technique du Bâtiment (CSTB), Public Industrial and Commercial Company (EPIC), whose ambition is to support and ensure sustainable projects for the construction and renovation of infrastructure in cities. CSTB has developed a systemic approach that integrates all sociological, health and comfort, environmental and energy, economic, and safety issues that apply to buildings, neighborhoods, and cities. eveBIM is a free desktop application for viewing and understanding digital BIM models in the standard IFC and CityGML format. Of the various functionalities in this solution, the following are of particular relevance:

- Georeference the IFC model: Allows you to change or add the coordinates of the model's position in the world, defining the longitude, latitude and elevation.
- Measurements: Allows you to measure the distance between two points, the length or width of a wall that makes up the model.
- Load multiple IFC files: Allows viewing of multiple IFC files loaded in the application.
- Exploding/Deconstructing the model: It consists of separating the elements that make up the model in order to be able to analyze the elements individually. There are several levels of model deconstruction that can be changed vertically and horizontally.
- Add Annotations: Allows you to place annotations and comments on the feedback of changes made in a collaborative way.
- Import and Export of files: Allows you to export the properties of all model elements to an excel file (.xlsx) and import files in IFC, CityGML, Orthophoto, Point cloud, Shapefile, Terrain and VTP format.

### 3.4 UsBIM.viewer+

Founded in 1989, ACCA Software has established itself in the software industry in the AEC area by its ease of use, innovative approach, pragmatic attitude, strong drive for innovation, and ability to respond adequately to the growing needs of professionals. In 25 years of activity, they have developed more than 90 different software solutions for the AEC sector, such as architectural design, budgeting, structural calculation, maintenance, and security. In 2018, it became the company with the largest number of certified BIM software globally. Developed by ACCA Software in 2018, usBIM.viewer+ is a free desktop application that allows you to view, edit, convert, read and share IFC files being certified by buildingSMART International. The features that stand out in this software are:

- Load multiple IFC files: Allows viewing of multiple IFC files loaded in the software.
- Convert Files: Allows you to convert 3D model files (DWG, SKP, OBJ, 3DS, Collada, Revit) to IFC format.
- Edit Model:
  - Removing Elements - Allows you to remove elements from the IFC model.
  - Adding Elements - Allows you to import 3D models and add them to the file as IFC elements.
  - Elements Update - Allows you to change the position and rotation of elements or change their geometry to a 3D model without losing their properties.

- Adding, Removing and Updating Element Properties – Allows you to add, remove and update existing properties on elements.
- Measurements - Allows you to measure the distance between two points, for example the length or width of a window.

### 3.5 Comparative Analysis of the Analyzed BIM Platforms

All platforms mentioned in the previous subsections were compared to analyze and determine a set of base features and corroborate the need for innovative features to support the solution proposed in this document. This analysis focuses on the determination of requirements given as acquired by users of BIM platforms, and on the exploration of new ones that can encourage users to use the software to be developed. Table 1 summarizes the analysis carried out between the BIM platforms, gathering the aspects that are most relevant to the development of the solution proposed in the document.

Table 1. BIM Platforms comparison

	Autodesk Revit	Autodesk Viewer	BIMvision	eveBIM	usBim.viewers
Web application?	No	Yes	No	No	Yes
Open-source software?	No	No	Yes	No	No
Can load multiple models?	Yes	No	Yes	Yes	Yes
Fast?	No	Yes	Yes, but has premium functionalities	Yes	Yes
Can edit elements of the model?	Yes	No	No	No	Yes
Load time of files?	Fast	Slow	Fast	Medium	Medium
Can georeference the models?	Yes	No	No	Yes	Yes
Can work collaboratively?	No	Yes	No	No	No
Space occupied on disk?	30GB	0KB	200MB	660MB	600MB
Crossplatform?	No	Yes	No	No	No
Performance with big models?	Fast	Doesn't work	Medium	Slow	Medium

## 4. SOLUTION

The proposed solution consists of the development of a 3D Digital Twin platform for representation and collaborative editing of IFC documents, applied to the BIM methodology. It allows concentrating the information of the projects in a digital form, incorporates all its participants, and promotes the collaboration between the diverse work teams.

### 4.1 Requirements

To ensure effective development of the solution, it is necessary to know the determining characteristics for the product and/or service to succeed and be adopted by the market. The functional and non-functional requirements presented form the minimum set of objectives to be achieved so that the platform can be competitive in the current market for BIM solutions.

**4.1.1 Functional Requirements** Functional requirements represent the concrete functionalities of the system. They are essentially the specifications of the users, and the set of characteristics and uses that they intend to have in the solution. The functional requirements of this project are as follows:

1. Register an account on the platform.
2. Login and Logout from the platform.
3. Create Projects.
4. Delete projects.
5. Associate users with projects.
6. Load IFC models.
7. Visualize IFC models.
  - (a) View multiple IFC models at the same time.
8. Collaborative editing of IFC models.
  - (a) Load new revisions.

- (b) Consult revisions.
- (c) Georeference the models.
- (d) Delete models.
- (e) Remove elements from IFC models.
- (f) Add elements to IFC models.
- (g) Update elements of the IFC models.
- (h) Save the changes made in a new revision.

**4.1.2 Non-functional Requirements** Non-functional requirements represent how the software works, such as performance, usability, reliability, security, and maintainability. To identify these requirements, the FURPS+ model was used, which allows classifying the quality attributes of the software, having identified the following non-functional requirements:

1. Solution based on Web technologies.
2. Solution can be used on multiple platforms.
3. Flow in the use of the solution.
4. Appropriate messages for the user in case of failure and success.
5. All system components must work isolated.

### 4.2 Solution architecture

Regarding the overall architecture of the solution, it is possible to verify the orchestration of the various components that make up the system and the technologies on which they are developed. The selection of the technology stack consists of the combination of selected technologies in order to offer an overview of the programming languages inherent to the system, identifying the main structural components of the system, and their respective connections, from user interaction to the base of the system data. Figure 1 presents the technological structure of the solution, detailing the technologies used in each layer, as well as the communication between each of the levels:

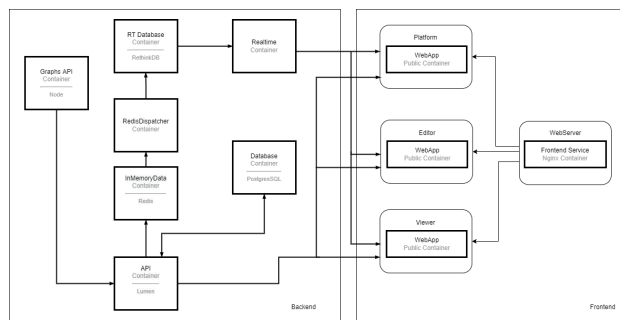


Figure 1. Solution Architecture.

Through the analysis of Figure 1, it can be concluded that the solution is based on micro-services, and defined by the following components:

- **RT Database** – Stores messages for real-time distribution.
- **InMemoryDatabase** – Temporary storage of cache and message broker.
- **RedisDispatcher** – Subscribes to message broker channels and publishes in RT Database.
- **Realtime** – Disseminates the messages in real time.
- **Database** – Stores relational and spatial data.
- **API** – Mediates the access to the database and business rules.
- **Graphs API** – Processes sensor data.

- **Platform** – Construction project management platform.
- **Viewer/Editor** – 3D Digital Twin platform for viewing/editing IFC documents.

In the scope of this work, only Viewer/Editor applications will be studied.

### 4.3 Viewer/Editor

The Viewer/Editor applications are based on the same functionalities, being the following:

- Representation and visualization of IFC models.
- Visualization of IFC model elements data.
- Movement in the 3D scene.
- View IFC model revisions (Figure 2).

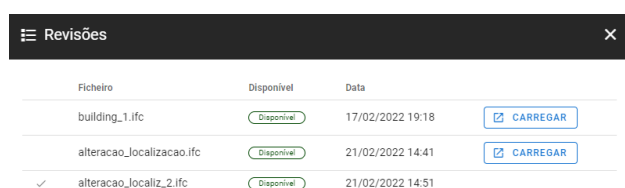


Figure 2. IFC revisions available to load in the 3D scene.

The Viewer has features focused on the analysis and comparison of loaded IFC models, unlike the Editor which focuses on editing geometry, georeferencing the IFC document, and filling in metadata.

The features that characterize the Viewer are the following:

- Visualization of the IFC model elements tree.
- Comparison of models from different specialties.
- Load the IFC model in different LODs (Level of Detail) - Figure 3.

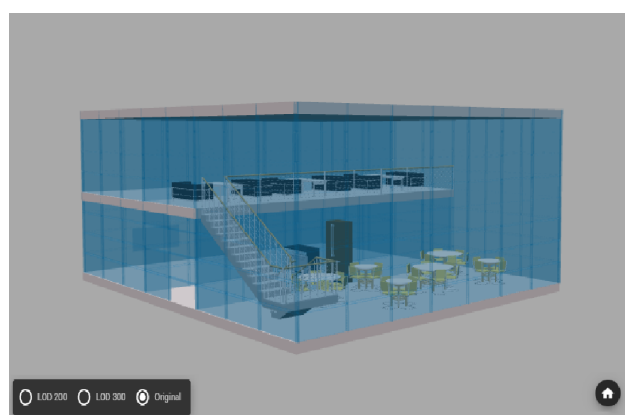


Figure 3. Viewer- IFC 3D rendering.

The specific features of the Editor are as follows (Figure 4):



Figure 4. Editor user interface.

- Georeferencing of the model following the IFC standards (Figure 5).
- Editing geometry (translation, rotation and scale of elements and the IFC model).
- Editing metadata (addition, removal and updating of element properties and the IFC model).
- Model plane cut.
- Removing and adding 3D elements from a 3D model catalog (Figure 6).
- Measurement of 3D model elements (Figure 7).



Figure 5. Georeferencing a 3D model in Editor.

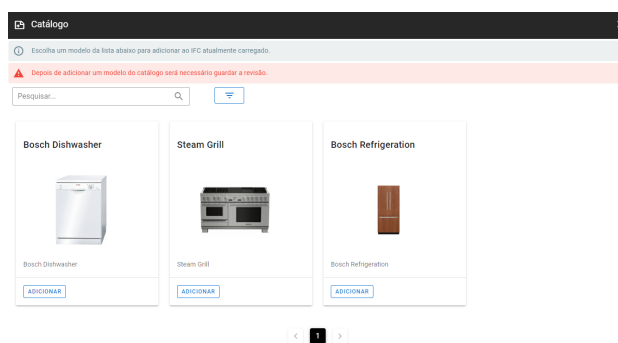


Figure 6. Editor Catalog interface.

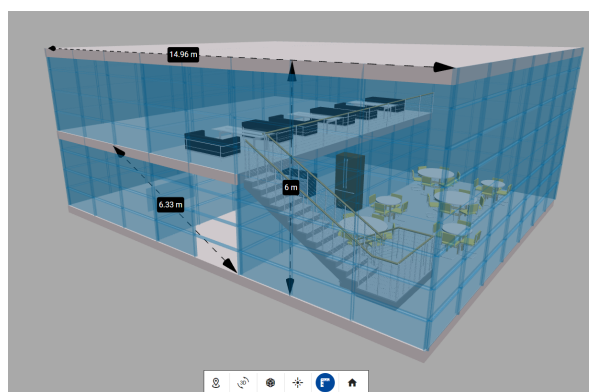


Figure 7. Taking measurements of an IFC model.

These two applications work fully on the web, compatible with all modern browsers, quickly and efficiently, allowing and facilitating the collaboration of multidisciplinary projects in the AEC sector.

Once the responsibilities assigned to the different components

that make up the system and the way they interact with each other are identified, the Sequence Diagram is presented to exemplify the process of georeferencing a 3D model in the IFC format, using the Editor component (Figure 8):

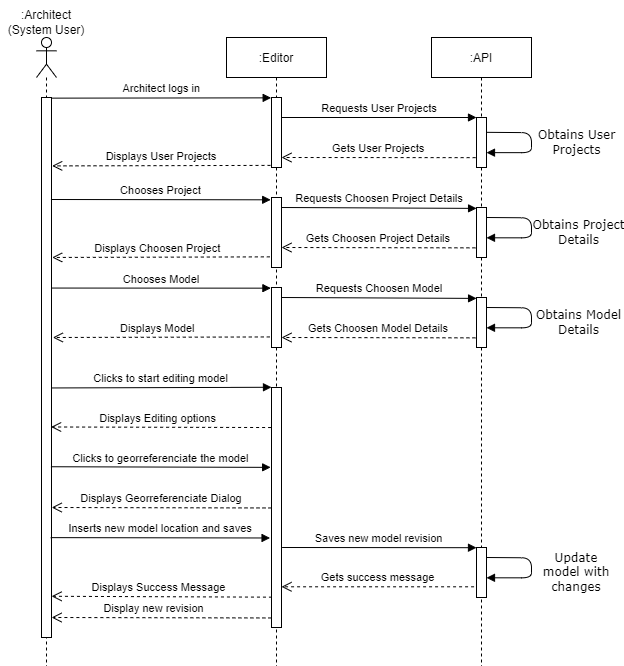


Figure 8. Sequence Diagram representing the process of georeferencing a 3D model.

## 5. CASE STUDY

In this section, we describe the case study with the proposed system solution. The target of this implementation was the mobilizing project REV@CONSTRUCTION, composed of several companies in the AEC sector. REV@CONSTRUCTION is one of the main drivers of the digital transformation of companies in the AEC sector, with 3Maps being one of the partners in the project, which is the taker of innovation and producer of the solution.

This project is, therefore, the early adopter of the solution presented here, and aimed at implementing this platform in order to enable the control and management of projects, processes, and people. In this way, as expected, the solution provides a wide range of components that support the activities of the different identified business processes and that allow integrated and centralized management of all the information, giving effective support to the decision, such as, for example, the concession of infrastructures, the georeferencing of infrastructures, in addition to monitoring and planning in real-time, of all stages of a construction project.

## 6. CONCLUSIONS AND FUTURE WORK

The case study presented here was essential to validate the positioning of the solution. The existence of a problem in the AEC sector has been proven by the scarcity of products, processes, and services that enhance collaboration, training, and innovation in the sector, in order to compete in the global market. The solution proved to be capable of giving an effective response to the needs and whose adaptation of the generic proposal to the

case study was well achieved, it is believed that this will be a unique solution, easy to apply, to any construction project regardless of its dimension, and which will provide the AEC sector with efficient support in the execution of activities arising from the construction processes.

The developed platform will be available openly to all companies that want to engage in the BIM community and ought to actively participate in and foster the development, improvement, and promotion of this platform within the AEC sector.

In terms of future work, we intend to extend the solution in terms of features and improve its performance, as well as continue to integrate more and more companies to the BIM reality.

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