GEOFIT Project creating the opportunity of Geographical – BIM (GEOBIM) platform to manage geothermal systems

Ramon Juan [1], Velásquez Sergio[2]

[1] IDP Group (Spain), Torre Mil·lenium; Av. Francesc Macià, 60 3rd floor; 08208, Sabadell; Barcelona, Spain

[2] COMET Global Innovation (Spain), Carrer Gran de Gràcia 1-3-5, 4rt 3ª, 08012 Barcelona, Spain

jramon@idp.es; s.velasquez@comet.technology; sergio.ivan.velasquez@upc.edu

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ABSTRACT

Within the GEOFIT project (Smart Geothermal Systems[1]), BIM environment has been defined as GeoBIM platform. This term refers to those specific geothermal applications which are included in a tailor-made BIM platform to manage the geothermal systems, building, site and assets information from models, sensors installed and simulations. In GEOFIT project, the demo-sites location is enriched up to the holistic view of the retrofitted buildings with all the geothermal facilities designed, simulated, installed, commissioned, and monitored, from inception onward, during the lifecycle of a facility and includes all stakeholders who need facility information – from the designers to the occupants with the building in operation. This holistic view includes the execution control and the permanent geographical reference because the simulation, monitoring and design processes happen in a specific geographical context. The definition and implementation of a GEOBIM platform is paramount for the project and it is one of the main outcomes of GEOFIT project. While BIM implementation is ubiquitous in the architectural issues of the project, relying mostly on CAD designs, geographical information has a limited role particularly in construction projects, it is often restricted to some specific tasks or seen as a potential redundancy to BIM. Considering the geographical dependent tasks in GEOFIT, GIS can bring a valuable complementary contribution to the BIM process by providing spatial input and geospatial visualization, adding information on the retrofitting demo-site's surrounding environment and underground thermal information that is essential for design decisions and the approval processes regarding building integrity and geothermal energy availability. In this paper, an interdisciplinary cooperation, data exchange, and data transfer occurs among the different professionals and disciplines involved for the successful retrofitting project planning and energy efficiency demonstration throughout the GEOBIM platform. This is implemented to assemble this set of powerful assessment, inspection and ground research, testing, and real time monitoring tools.

1. INTRODUCTION (CHAPTER TITLE, BOLD CAPITALS, 3 PT SPACING BEFORE AND AFTER)

GEOFIT is an EU-funded innovation project. Its objective is to develop an enhanced geothermal system (EGS) to be used for energy-efficient building retrofitting and to deploy this system in cost-effective conditions. Retrofitting is a complex and holistic process where any decision must be taken by considering a large diversity of constraints, stakeholders, and specific objectives. It is needed to devise an enhanced methodology, supported by an appropriate suite of tools, encompassing new concepts for comprehensive retrofitting that will satisfy occupant requirements and comfort needs while also achieving substantial reductions in energy use.

The holistic view of the retrofitted building with all the geothermal facilities installed, commissioned, and monitored, from inception onward, during the lifecycle of a facility, includes all stakeholders who need and provide facility information – from the designers to the occupants with the building in operation. This holistic view includes the execution control and the permanent geographical reference because the simulation, monitoring and design processes happen in a specific geographical context. Most construction project designs are built with CAD programs (e. g., Auto-CAD) by planning engineers and architects. Environmental and landscape planners, on the other hand, use GIS to assess the environmental impacts of

[1] European project that has received funding from the European Union's H2020 programme under Grant Agreement No. 792210

the construction projects and the visual, ecological, and functional integration of the project in the landscape. To meet all requirements, the CAD datasets from engineers and architects must be converted to GIS formats and combined with GIS datasets from environmental and landscape planners, so that the necessary analyses can be performed.

2. GEOBIM PLATFORM CONTEXT

Retrofitting projects are usually at loss of proper documentation from which to start with, but if this happens in this context, in the field of underground works, this lack is even greater. Following this argument, the scope of this paper is to define a set of procedures and tools related to data acquisition from subterranean affected areas, works performed in the terrain, geothermal systems and equipment installed, as well as their linking with current GEOBIM Open Standards to enable the potential use of the available information of the different elements for the integration of the BIM designed systems for the geothermal facilities implemented in the demo sites used in this project.

Geographic information systems or geoinformation systems (GIS) have been used for long to model the environment and to perform 2D spatial analyses of large areas. However, with the increasing availability of computing power, advanced data acquisition methods, and automated workflows that generate detailed 3D data, GIS models have become increasingly detailed and started to contain models of individual buildings—the traditional domain of building information modelling (BIM).

At the same time, the increase in computing power and the availability of better software have enabled BIM methodologies to move to the mainstream, disrupting more traditional building design platforms based on 2D CAD drawings.

As users of BIM software want to incorporate the surrounding features into their workflow, it is only logical that the BIM domain is currently enhancing its standards to support environmental information such as infrastructure and that BIM users turn to existing GIS datasets containing environmental information. Both domains are thus now overlapping, increasingly modelling the same objects, even if the data is represented and stored in rather different ways [1].

By integrating the BIM planning processes into a geodatabase structure in a collaborative planning system (GEOBIM Platform), the corresponding information can be exchanged and processed smartly. This approach can be used for buildings, civil engineering projects, urban development, energy efficiency in urban areas and particularly, GEOFIT project. For this purpose, 2D and 3D CAD, and BIM data models coming from the previous design stages are integrated into the GIS data model – in full or in parts – and then assessed.

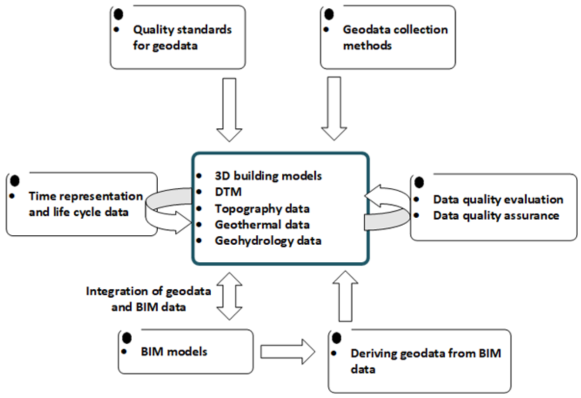

Figure 1. Information workflow in a GEOBIM project. Source: own elaboration

Figure 1 shows a 3D building geodata and a digital terrain model (DTM), applied to GEOFIT; the aim of this concept is to enhance the sharing of this information in the retrofitting environment process and also to integrate it with the BIM-data. To enable this sharing and integration of information it is required to know the quality of the data. Therefore, the process requires to describe the geodata collection methods with focus on collecting building data and DTMs, and other geodata required for composing the whole GEOFIT scenario. It is also important to include the possibility to derive the building geodata from BIM-models by means of a BIM2GIS/GIS2BIM enabling tool.

3. GEOBIM PLATFORM DEVELOPMENT

The information sources, the data exchange requirements and the common data environment have been widely discussed during the initial stages of the GEOFIT project, through the definition and design of the Integrated Design and Delivery Solutions (IDDS). To design and implement the common data environment in a GEOBIM platform, GEOFIT project provides different solutions according to four technology drivers as follows:

3.1. Tools and methods for viable and cost-effective geothermal retrofitting

- Drilling Techniques: drilling around built environments where space and depth are scarce and/or the soil characteristics are not suitable for traditional solutions.
- Structural Health Monitoring tools and methods: Safe integration of EGS new technologies in historical or other buildings sensitive to vibrations or earth movements.
- Geothermal and Seismic Retrofit monitoring: Risk assessment and evaluation of building "health" after a retrofit or a catastrophic event for insurance purposes.

3.2. Efficient geothermal systems and its components

- Thermally driven Heat Pumps: integration of couple thermally and electrically driven heat pump in residential buildings
- Electrically driven Heat Pumps: integration in tertiary or industrial buildings especially when they are equipped with PV to supply the electricity.
- Heat Exchanger (HEX) compact configuration using aluminium: goal here is to decrease the global cost of the heat pump without reducing the efficiency.
- Heating and Cooling (H/C) solutions: modular solutions for Low-temperature heating and high-temperature cooling contributing to improve global efficiency and reduced costs.

3.3. Integrated retrofit management framework based on IDDS

- GEOBIM platform: comprehensive and Integrated decision support on retrofitting projects. Multi-scale, multi-criteria analysis for retrofit planning.
- UAVs for GEOBIM: Non-invasive, fast, and cheap creation of BIM geometrical model. Used also in hazardous or hard to reach zones.
- Demonstration, exploitation, and innovative business models
- Business models around flexibility services: consultancy on flexibility services and their advantages.
- Intelligent BEMS: Unlock the potential of offering flexibility services to the grid while improving system performance, environmental conditions and reducing energy bill.
- Algorithms and models for flexibility operation: forecast and balance energy use with generation. Be able to offer flexibility services to the grid. Be able to present data in a user friendly and didactic way to encourage prosumers

The implementation of the common data environment is a complex process and information comes from very different fields. Data provided and exchange has in most of the cases a geographical attribute and other data is provided in terms of CAD models for each demo-site. These data provisions are the basis to create the GEOBIM environment within the GEOFIT project context.

4. INFORMATION AND DATA REQUIREMENTS

To solve the data management issues, different land data and information is considered. GIS has been known since 1968 and the modern GIS techniques can achieve most data digitalization. GEOFIT also has defined an information delivery methodology for its application for efficient management of borehole and geological data during drilling process. [2].

By the other hand, Building Information Model (BIM) has been considered as an important technology to be applied in GEOFIT. Current developments and applications of BIM demonstrate that not only it is useful for geometric modelling of a building's performance, but it can also assist in the management of engineering projects during and beyond their life cycle. BIM-based framework is used to support safe maintenance and repair practices during the facility management phase of industrial or civil projects. Compared to GIS, BIM is built on the data model Industry Foundation Classes (IFC), which allows different kinds of software to share data. BIM is usually applied in the buildings and concentrates on construction and safety management. As a result, an integration platform of GIS and BIM can not only store the projects lifecycle data in organization, but also provide spatial analysis and performance analysis. The data visualization, retrofitting project progress, spatial and energy efficiency analysis and retrofitting performance analysis are expected to be implemented in the GEOBIM platform.

4.1. 3D Building Models and 3D Building Geodata

3D building models provide a digital representation of part of the urban environment. The models are used for an increasing number of applications from construction to maintenance or renovation. To support the diverse use cases most municipalities and industries in Europe have created 3D models of several facilities including cities, commercial areas, industrial infrastructures and also transport infrastructures. There is a growing number of commercial and public models and models based on crowd sourced data.

3D building geodata could be derived from BIM-models or by using geodetic surveying methods. A common methodology for the latter case is to utilize building footprint data (from e.g., a detailed municipality map) with surface data collected from airborne laser scanning or photogrammetry.

GIS and gbXML

The Green Building XML schema (gbXML) is an open schema developed to facilitate transfer of building data stored in Building Information Models (BIM) to engineering analysis tools. gbXML is being integrated into a range of software CAD and engineering tools and supported by leading 3D BIM vendors. gbXML is streamlined to transfer building properties to and from engineering analysis tools to reduce the interoperability issues and eliminate plan take-off time. gbXML is the underlying architecture of Autodesk's Green Building Studio commercial on-line energy analysis product and is the main export option for energy analysis from their modelling products [3].

5. BIM MODELS

Building Information Models (BIM) are digital representations of buildings in the different lifecycle phases from design through construction to operation and maintenance. The main usage is to support the development of the design model of the building – to define goals for the production based on the requirements from the different stakeholders, which are customers, clients, owners and the society with building regulations and codes.

Another use of the BIM model is to support construction activities. In this case the executional model is developed to guarantee a result as accurate and loyal to the design as possible. After that the model can be used for operation and facility management.

The models can store and exchanging information on building element level as well as on aggregated levels for analysis and simulations. In addition, other information types like time and cost can be linked.

Within GEOFIT project, BIM models create the base of the common data environment of GEOBIM platform.

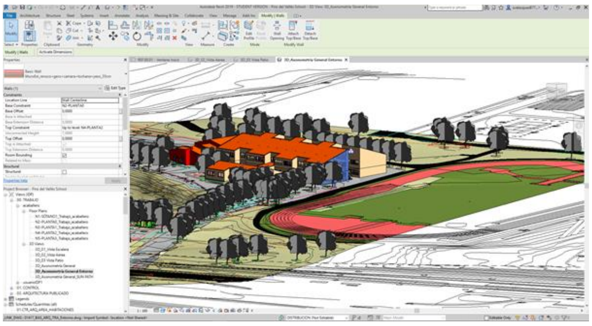

Figure 2. Figure 2. Pins del Vallés School at Sant Cugat, Spanish demo-site. The model includes topographic map of the School surroundings. Source: BIM Model provided by IDP

5.1. BIM Standards

There are several international BIM-data standards used widely when designing and modelling with BIM data to satisfy different building services and requirements.

ISO/TS 12911:2012, Framework for building information modelling (BIM) guidance

This basic standard establishes a framework for providing specifications for the commissioning of BIM, which can be used for the information manager and for BIM guidance provided by application providers. It is applicable to any asset type, including most infrastructure and public works, equipment and material. Any range of modelling of buildings and building-related facilities is also applicable, from a portfolio of assets at a single site or multiple sites, to assets at a single small building and at any constituent system, subsystem, component or element.

ISO 16757-1:2015, Data structures for electronic product catalogues for building services -- Part 1: Concepts, architecture and model and ISO 16757-2:2016, Data structures for electronic product catalogues for building services – Part 2: Geometry

The ISO 16757 series is a multi-part standard, and the purpose is the provision of data structures for electronic product catalogues to transmit building services product data automatically into models of building services software applications. It includes two parts: Part 1 specifies the basic concepts, and a framework for the specification of the Content Parts by describing the elements which are to be provided by these Parts; Part 2 describes the modelling of building services product geometry optimally.

ISO 29481-1:2016 (first edition ISO 29481-1:2010), Building information models -- Information delivery manual -- Part 1: Methodology and format and ISO 29481-2:2012, Building information models -- Information delivery manual -- Part 2: Interaction framework

The ISO 29481 series provides a basis for reliable, accurate, repeatable and high-quality information exchange/sharing for users, including two parts:

Part 1: Methodology and format, is intended to facilitate interoperability between software applications used during all stages of the life cycle of construction works.

Part 2: Interaction framework, is intended to promote digital collaboration between actors in the building construction process.

5.2. Industry Foundation Classes (IFC)

IFC is an open, formal, international, consortium standard currently involved in a hybrid standardization process designed to enable indirect horizontal compatibility between architecture, engineering, and construction (AEC) and facility management (FM) software applications.

ISO 16739:2013, Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries. The standard specifies a conceptual data schema and an exchange file format for BIM data and represents an open international standard for BIM data that is exchanged and shared among software applications used by the various participants in a building construction or facility management project.

IFC is primarily using constructive solid geometry (CSG) based on primitive solids (cylinders, rectangles, etc.) but could also include B-rep models. The standard is specified by BuildingSMART, see e.g., BuildingSMART (2018) for an overview.

5.3. Digital terrain models

Since the 1990s, Digital terrain models (DTM) has played an indispensable role in all geosciences and engineering, such like: urban planning and construction, military engineering, spatial analysis, civil infrastructure planning and design, terrain analysis, 3D modelling, computer games and so on. In GEOFIT project, each demo-site was supposed to provide its own DTM officially acquired from the local geographical administration or public cartographic services.

In case of the Sant Cugat Pilot, the DTM was provided as a DGN file, this file was introduced in the BIM model as a reference. This allowed the positioning in X, Y, Z coordinates of the boreholes and vertical HEX.

6. INTEGRATION OF GEODATA AND BIM-DATA

In recent years, there has been a trend of integration of BIM-data and geodata. Only using one technology, BIM or GIS, cannot meet and satisfy the need in the whole life cycle of construction. The interest in BIM-GIS integration has increased sharply because of their similarities; using spatial data, constructing building or infrastructure models, and visualizing in different level of details. As it has been discussed previously, the integration is not simple due to the dissimilarities between BIM and GIS, for example spatial scale, level of granularity, geometry representation methods, storage and access methods as well as semantic mismatches between their data models.

The integration at the process level can be done using semantic web technologies such as reference ontologies. A reference ontology can contain the concepts of both IFC and GIS and is able to store their differences, and by that it can be part of the development of a seamless integration system.

Ontologies are flexible, but a drawback is that it is costly to develop ontologies and that they often only are suitable within a specific domain. Another way of integration at the process level is by using services. Here the OGC Web Feature Server (WFS) and the transactional WFS for BIM have been used to serve features from IFC and GIS. This method is effective for both semantic and geometric conversion and the information loss is low, but this solution is static and involves system development. GOBIM platform shall be implemented with the most suitable GIS data format to integrate BIM information.

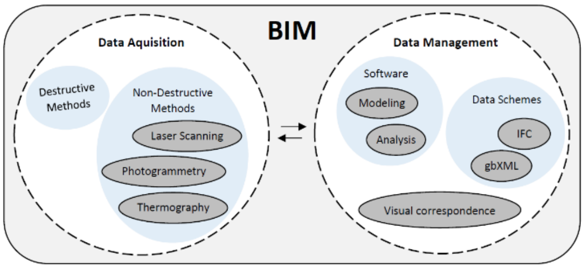

Figure 3. As-built BIM methodologies for retrofitting. Source: Ref. [4]

8. DEMONSTRATION ON DEMO – SITE GEOTHERMAL – BASED RETROFITTING – SANT’APOLLINARE FORTRESS, PERUGIA, ITALY

Typology: Historic building of cultural value; **Climate condition**: Humid subtropical climate; **Relevant Installation**: Centralized – Biomass; **Total energy consumption per year**: 24.971 kWh/year (representing about 29% of the total consumption of the whole complex); **Geological data**: Alternation of gravel and asphalt with rock bed in the underground.

Rock drilling and seismic retrofitting:

- Drilling technique used: shallow slinky heat exchangers
- Main system to be installed: Hybrid system, BEMS, LTH
- Manager: UNIPG
- Main Industrial Partners Involved in the demonstration: R2M, COMSA, IDP, SIART

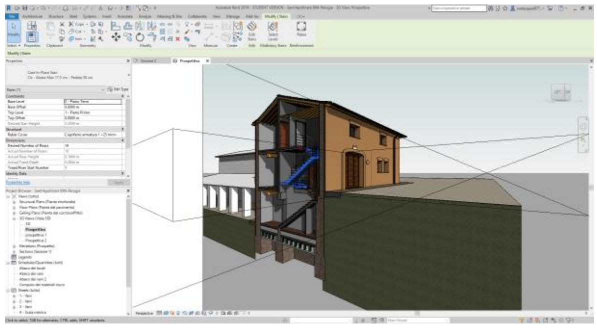

Figure 4. Revit model of Sant’Apollinare Fortress, Perugia, Italy. Source: BIM model provided by University of Perugia

8. GEOBIM METHODOLOGY

The methodology applied covers the following tasks:

- Analysis of the geoinformation, BIM models and new CAD objects available. It includes IFC models, geodata, 3D models, DTM, terrain surveys data, etc.
- BIM to GIS and GIS to BIM processes
- Data storage (object-oriented library defined in D6.2)
- GEOBIM data quality evaluation
- Monitoring

9. DATA COLLECTION

Digital Twin Instances (DTI) are simply cases or occurrences of anything happening in the physical asset represented in the digital ecosystem. In the Digital Twin world, this could be an element, an IFC file as input data, JSON identifier, or documentation that conforms to a particular data type definition (DTD).

This DTI information and data is collected and recorded from the physical asset and its elements through a series of Digital Twin Instances Tools. These tools are collecting and recording the data to be integrated into the GEOBIM Platform ecosystem dashboard as charts and tables in the DT viewer to identify possible variations during a time interval.

9.1. Monitoring Plug-In

During the GEOFIT Project, in the Perugia Pilot, UNIPG has developed a Plug-in which connects the sensors installed in the Building with the BIM model.

The H2BIM plug in proposes a methodology able to evaluate the structural integrity of historic buildings and the human-centric comfort of their occupants. It was implemented within the Autodesk Revit environment (2021 version).

The Revit add-in application, named” H2BIM” exploits the pyRevit plug in to allow an efficient processing of the monitoring data. All the scripts exploit dedicated graphic user interfaces, and they are written in Iron Python language, calling several external C Python routines.

All the collected and processed data can be exported in csv format using the same routines if required by users.

Thanks to the theorized workflow, it is possible to access and plot data by directly operating in Revit environment using several pushbuttons categorized in two main sections:

Structural monitoring and Human-Centric Comfort evaluation.

The first application of H2BIM is about the case study building comprised in the medieval complex of Sant’Apollinare Fortress

9.2. Data Storage

The information collected from existing building in the GEOFIT demo-sites, is as follows:

- Land information, topography, geotechnical
- Basic layouts (CAD files)
- Existing BIM models, REVIT/Archicad
- BEMS information
- Drilling and while drilling data exchange to protect historical buildings
- New GEOFIT systems designs and elements that have been implemented in the GEOBIM platform (CADs, PDF, sensor data files, etc.).
- Information provided by simulations

All data collected has been used to parameterize elements that make up the BIM models of the real demo-sites.

Following the Information Delivery and Exchange methodology a Library Manager has been considered as an application for the Master Data Management. Such data comprises the core, conceptual, entities of organisations. Because these data are about core entities, it is necessary to re-use these data across multiple applications to manage of modelling information more efficiently. To re-use information, a library of data is needed from which applications and people can gather information when required.

9.3. Object type Libraries

Next to be a user-friendly manner of creating these libraries, a Library Manager allows for sharing these libraries in an open standard: Linked Data. This open standard works on the internet protocol, and makes it possible to share information without any vendor lock-in. Conversions to other (open) data-formats are possible as well. Next to being open, Linked Data allows for specifying formal logic, such that computer can interpret the data and verify and validate the data.

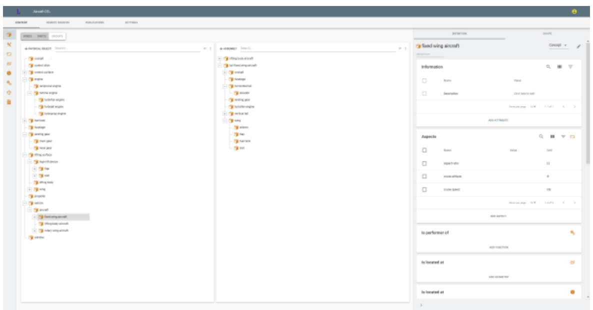

Figure 5. GEOFIT BIM Library Manager based on OTL (Object Type Library). – Source: SEMMTECH – https://semmtech.com/

9.3. Repository

Each GEOBIM project has an associated repository, which allows the user to create folder structures. The project information must be first structured properly.

Then, a “new” button allows the user to add the files according to the folder selected.

In the GEOFIT project there is no repository created yet.

The functionalities and steps to follow for uploading, downloading, and updating documents are described below:

Creation of the project structure: it is recommended to analyse the project and the different disciplines that associate it, with this the user must create at least one folder to store the documents. If the repository associated with the project does not have a folder structure, by default it asks to create at least one. Additional functionalities associated with the new dropdown for Create Folder or Load File are added.

10. GEOBIM PLATFORM ARCHITECTURE

The GEOBIM platform conceived now as a digital twin (DTwin) considers the scalability and flexibility of the data integration and analysis tools development to support interoperability. The design inputs come from:

a. Boreholes and excavations information
b. Geothermal heat exchangers designs
c. Ground source heat pumps designs
d. Heat pumps designs
e. Heating and cooling systems designs
f. Sensors’ information

The GEOBIM Platform serves as a Digital Data Generator and Digital Data Manager of all the data of a Building Digital Twin during his entire life cycle. Furthermore, the GEOBIM Platform DTwin links the BIM technology and the GEOFIT User Interface.

The main goal of the GEOBIM Platform DTwin is to authenticate and access asset data of the model.

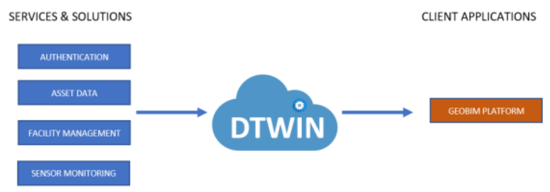

Figure 1. GEOBIM framework. Source: own elaboration

11. GEOBIM PLATFORM – MAIN SITE (PLACED ON CLOUD VIA WEBSERVICES)

This is the main site where a user can view all their projects associated with the application, which will be located and identified with an icon on the map. Each icon represented on the map reacts to the click event made with the mouse, which displays a pop-up window associated with the selected icon, listing the description of the demo-site, the applied solution, and a Viewer button, which allows navigating to the tab where the digital model is found with the functions assigned and applied to the demo-site.

It is mentioned that the Viewer button is the only gateway to be able to navigate to the tab where the model of the selected demo-site is located, giving as an example that if a client has created 5 projects within the application, to access each of them must be done through the Viewer button.

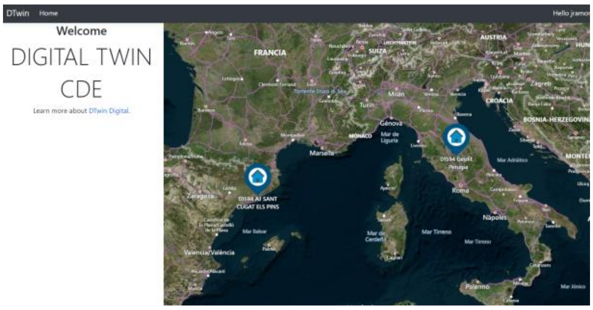

Figure 7. Home, sites visualization

11.1. Main menu - Solution Viewer and Integration

This tab contains the 3D model and implements the integration of the solutions applied to the demo-site, it divides the main container into two sources of information, the left container, which is defined as an information panel, which refers to all the associated integration modules to the pilot and the right container to the 3D model, which is defined as a 3D viewer.

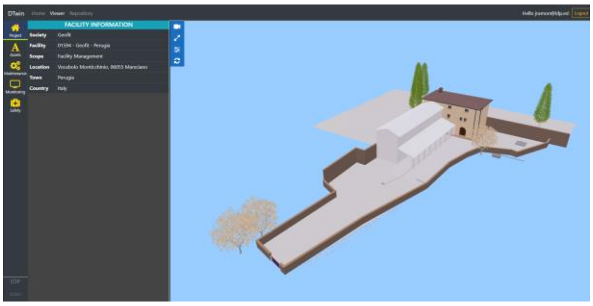

Figure 2. 3D Viewer

Depending on the integration modules associated with the project, they will be loaded in a sidebar located on the left side of the information panel, each item contained in the sidebar will refer to the information and integration module assigned to the pilot.

In the GEOFIT Project, the following information and integration modules have been assigned, which are listed below.

11.2. 3D Viewer

The 3D viewer allows you to interact with the user through the model, for this it has navigation controls that can be exchanged through the buttons found in the upper left part of the 3D viewer. The navigation controls are described below:

- Button that allows you to exchange the camera from free navigation to first person and vice versa
- Allows to expand the viewer window to full screen and reset to its initial state
- Resets the initial position of the camera
- Free navigation controls

The 3D viewer uses the mouse for free navigation when the free navigation option is enabled.

Left mouse button: keeping the button pressed, allows the rotation of the model.

Double click, left button: It is used to select the objects in the viewer, previously the mouse cursor must be over the geometric element to select.

11.3. Project Information

Module that contains the facility information.

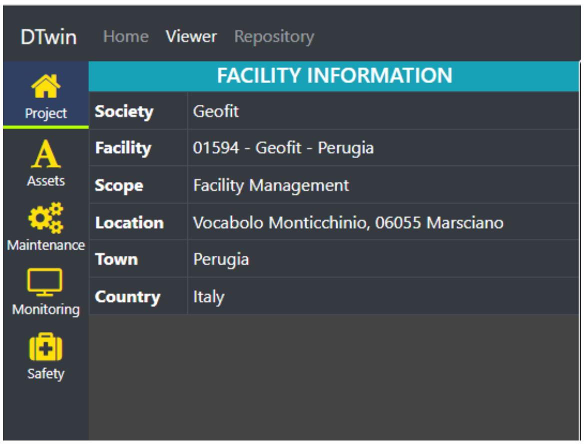

Figure 3. Project Information

Once the information from the asset is imported in the DTWIN must be authenticated, accessible, and filed to be converted into a virtual representation of the physical asset that will be accessible by the users through the viewer. This viewer allows the user to visualize the model created using the BIM methodology.

11.4. Asset Data and Facility Management

Once the information from the asset is imported in the DTWIN must be authenticated, accessible, and filed to be converted into a virtual representation of the physical asset that will be accessible by the users through the viewer. This viewer allows the user to visualize the model created using the BIM methodology.

Assets

Module whose function is to manage, create and consult the assets that are associated with an inventory and are linked to a geometric representation in the 3D model. DTwin considers as inventory:

- Any element that is part of a preventive maintenance plan.
- Any element that is part of the integration with monitoring systems.
- Any element that is part of the integration with existing RP, CRM solutions.
- Any element that is part of the integration with simulation systems.

This module contains the functionalities of Definition, Hierarchy, Inventory.

Inventory

This functionality allows you to list the inventoried geometric elements through a form that contains a dropdown with the hierarchy levels (previously created in Definition) for the grouping of inventories.

Note: the form contains a search option that allows you to search for inventories by name, type, or tag.

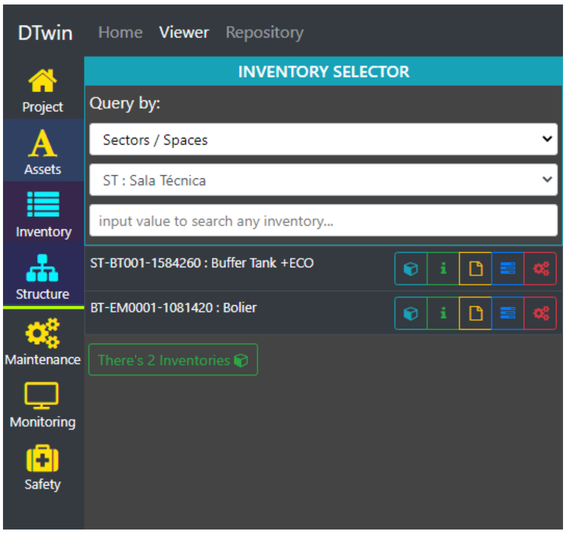

Figure 10. Inventory

Each listed element corresponds to the partial identification of the asset and contains a set of buttons that allow interaction with its geometric representation in the 3D viewer and the display of the information associated with the asset.

Object (element) in the inventory

The platform functions enable to focus on the element or groups of geometric elements related to the asset in the 3D viewer

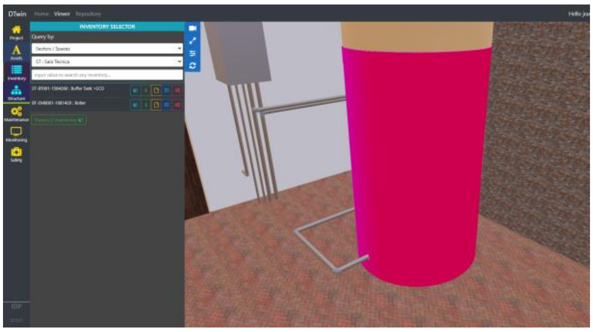

Figure 11. Buffer tank detail

The main information group contains the Edit Main Information button, which displays the INVENTORY MAIN INFORMATION - EDITION window that allows you to edit the asset information and the custom information group the edit custom information button (Edit Custom Information) which displays the editing window of the asset's custom information (INVENTORY CUSTOM INFORMATION - EDITION) that allows the editing and creation of new properties

As final considerations and part of the work still ongoing, the Monitoring module is being developed to allow the user to visualize the recorded data from the different assets or general data from the whole building. With this, the module has a set of functionalities that allow the monitoring of different KPIs of the different elements in the inventory or from the whole GEOFIT installed and in operation system.

The implementation of the GEOBIM Platform in two of the Pilots/Demo sites has been positive in general terms. The pilots and demo sites represent different types of buildings, one historical building which is used also for scientific purpose, and another public building for educational purpose. In the case of this paper, the historical building has been used. This demo site covers a wide range of the platform’s functionalities. The Perugia pilot has more data related to monitoring of the consumption and use of the new GEOFIT technologies applied.

12. CONCLUSIONS

The GEOBIM and the framework of solutions are represented by the DTwin ecosystem and the related ontology, which have been under development in the project. They represent the methodological and technical framework to enable and exploit DT solutions and services, in general and specifically for the tools and services developed in the project.

In the other hand, the effort for the technical development of the solutions related to the platform, the involved partners have been relevant actors and/or leaders for the exploitation of the platform. For the final version of the business model the consortium, and particularly the partners who contributed more to the platform development, will agree if the exploitation will be led internally, by some interested partners, or externally to the consortium, for example through the activity of the Building Digital Twin Association (BDTA) developed in the framework of the project and initially including all the consortium partners or through another specific entities thought for the exploitation of the platform.

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