



D1.2 – AccesS Framework architecture, use cases and master planning for demonstrators



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Authors List

Leading Author(s)				
First Name		Last Name	Beneficiary	Contact e-mail
Dimosthenis		Ioannidis	CERTH	djoannid@iti.gr
Panagiota		Chatzipanagiotidou	CERTH	phatzip@iti.gr
Ioannis		Koskinas	CERTH	jkosk@iti.gr
Napoleon		Bezas	CERTH	bezas@iti.gr
Elena		Conte	E@W	elena.conte@energyatwork.it
Luigi		D'Oriano	E@W	luigi.doriano@energyatwork.it
Guiseppe		Mastandrea	E@W	giuseppe.mastandrea@energyatwork.it
Co-Author(s)				
#	First Name	Last Name	Beneficiary	Contact e-mail
1	Dimitris	Tzilopoulos	CERTH	dimtzilop@iti.gr
2	Manolis	Zidianakis	FORTH	zidian@ics.forth.gr
3	Eirini	Kontaki	FORTH	ekontaki@ics.forth.gr
4	Ilias	Sarantakos	QUE	i.sarantakos@que-tech.com
5	Mija	Susnik	DMO	Mija@demobv.nl
6	Aliferis	Ilias	UNIS	botsisd@unisystems.gr
7	Dimitris	Botsis	UNIS	aliferisl@unisystems.gr
8	Mattia	Forni	LAMA	mattia.forni@agenzialama.eu
9	Harshita	Thakare	LAMA	harshita.thakare@agenzialama.eu
10	Raquel	Ortega Martínez	CETEM	r.ortega@cetem.es
11	Jose Francisco	Puche Forte	CETEM	jf.puche@cetem.es
12	Juan Carlos	Bañón Guillén	CETEM	jc.banon@cetem.es
13	Miguel Ángel	Silvestre Botella	CETEM	ma.silvestre@cetem.es
14	Desislava	Koleva	MoG	desislava@gabrovo.bg
15	Pencho	Koychev	MoG	p.koychev@gabrovo.bg

16	Margarita	Dorovska	MHS	director@humorhouse.bg
17	Miguel	Minano	MIW	miguel.m@miwenergia.com
18	Cristina	Marchante Garcia	MUR	cristina.marchante@ayto-murcia.es
19	Anna	Claudia	BARI	arcannaclaudiabufo@gmail.com
20	Luigi	Ranieri	BARI	luigi.ranieri@comune.bari.it
21	Garista	Fabio	VAIMOO	fabio.garista@angel4future.com
22	Rutigliano	Pasquale Dario	VAIMOO	dario.rutigliano@vaimoo.com
23	Manuela	Taverniti	FLO	manuela.taverniti@comune.fi.it
24	Francesco	Giuggioli	FLO	francesco.giuggioli@comune.fi.it
25	Roberto	Spini	FLO	roberto.spini@comune.fi.it
26	Guido	Van Arkel	BHA	g.vanarkel@bruco.org
27	Vito	Mario Fico	HIVE	vito.fico@hivepower.tech
28	Laura	Casolo Ginelli	HIVE	laura.casologinelli@hivepower.tech
29	Stefano	Mauri	AEM	smauri@aemsa.ch

Reviewers List

Reviewers			
First Name	Last Name	Beneficiary	Contact e-mail
Paris	Fokaides	FRC	eng.fp@frederick.ac.cy
Eleni	Apostolidou	FRC	res.ae@frederick.ac.cy
Speranta	Stomff	ASRO	Speranta.stomff@asro.ro

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Executive Summary

Deliverable D1.2 reports on the existing conditions of the pilots and overall targets and presents a comprehensive technical description of the project's components and solutions, as well as the specifications of its key functionalities. This deliverable, resulting from Task T1.2 and T1.3, spans the first nine months (M1-M9) of the project and serves as the foundation for the project's implementation plan, aligning pilot needs with a range of use case scenarios that the AccesS digital solutions can deliver. T1.2 aims to identify the existing conditions at each pilot site and detail the different targets of the foreseen activities reflected in relevant use case scenarios, while, the primary objective of T1.3 is to create a detailed system architecture that translates user requirements into precise technical specifications by leveraging the outcomes from T1.1 and T1.2, ensuring that the project components are aligned with user needs and the overall project goals.

A thorough analysis of the six pilot sites was carried out as part of T1.2, starting with a common questionnaire covering aspects of interest for both T1.2 and WP2, to optimize time and effort and merge requests to pilots in a common document. An exercise of mapping potential use cases to pilot characteristics and needs was performed in close collaboration with the technical partners while bilateral meetings with each pilot were organised to assess contributions and clarify aspects. This process resulted in a baseline description for each pilot including current situation, needs, digitisation level and available equipment as well as requirements in terms of accessibility to be addressed by the project. The level of detail provided for each pilot site and building depends on the amount of information available from the sites.

In parallel with the activities of T1.2, T1.3 started by mapping user requirements to system functionalities and technical specifications. This involves identifying and documenting user requirements and translating them into actionable system functionalities. It is crucial that these specifications are in line with the prioritizations established in T1.1 and T1.2. The next step was to design a comprehensive system architecture that is both modular and scalable. This involves breaking down the system into functional modules and components and providing detailed specifications for each of them. These specifications include general specifications for each software module, the harmonization of programming languages, the definition of interfaces, data encryption specifications (ensuring GDPR compliance), and the selection of adequate cloud storage solutions.

Additionally, Task T1.3 defines the technical requirements for interactions and software interfaces between individual components to enable their independent development. This is essential for ensuring that each component can be developed and tested independently before being integrated into the overall system. Furthermore, the task specifies data models to ensure efficient data exchange among devices, systems, and digital tools used in the pilot demonstrations. This involves detailing the architecture release plan, which outlines the steps and timelines for deploying the system components in a coordinated manner.

In summary, Deliverable D1.2 is a critical document that lays the groundwork for the project's successful implementation. By providing a summary of the pilot case studies and a detailed technical description and comprehensive specifications for the project's components, it ensures that all aspects of the system are aligned with user needs and project objectives. This deliverable not only defines the system architecture but also sets the stage for the subsequent development and integration of the project's components, ensuring a coherent and efficient pathway towards the project's goals.

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List of Acronyms and Abbreviations

Term	Description
ACN	Italian National Cybersecurity Agency
ADM	Architecture Development Method
API	Application programming interface
BEP	Building Energy Performance Simulator
BIM	Building Information Modeling
BOMS	Building and Operation Management Systems
BrancacciPOV	Brancacci Point of View
CADM	Core Architecture Data Model
CCAM	Connected, Cooperative, and Automated Mobility
CCC	Climate City Contract
CIM	Common Information Model
CNR	National Research Council
DHiLab	Digital Heritage Innovation Lab
DOA	Description of Action
DoDAF	Department of Defence Architecture Framework
ECT	Energy Comfortness Tool
ECD	Energy Comfortness Dashboard
EESDT	Energy Efficient and Sustainable Design Tool
EV	Electric Vehicle
FORS	Fiber optic reflectance spectroscopy
FT-IR	Fourier-transform Infrared Spectroscopy
FQP	Freight Quality Partnership
GCA	Green City Accord
GUI	Graphical User Interface
IAQ	Indoor Air Quality
IDP	Integrated Development Plan
IF	Infomobility Florence

IFC	Industry Foundation Class
IML	Information Management Layer
IN2CCAM	Enhancing Integration and Interoperability of CCAM eco-system
KPI	Key Performance Indicator
RES	Renewable energy source
RUP	Rational Unified Process
SUMP	Sustainable Urban Mobility Plan
SULP	Sustainable Urban Logistic Plan
TOGAF	Open Group Architecture Framework
UC	Use Case
UI	User Interface
UML	Unified Modelling Language
VH	Virtual Humans
VR	Virtual Reality
VUM	Virtual User Model
XRF	X-ray fluorescence
ZF	ZACHMAN FRAMEWORK

1 Introduction

1.1 Scope and objectives of the deliverable

This report demonstrates the pilot sites that will be used as case studies for the implementation of the AccesS framework and will also serve as the initial and definitive document for detailing the AccesS Framework Architecture, focusing on both technical and functional design considerations. A thorough analysis of each pilot site reveals the existing conditions as well as the specific needs and use case scenarios, that the several AccesS components can serve while it also provides a comprehensive set of system requirements, addressing functional and non-functional aspects.

The deliverable includes a detailed overview of the six pilot sites, analysing their current conditions. This analysis encompasses structural aspects, topology, energy performance, well-being, infrastructure, and equipment. Following the definition of the pilots, the deliverable presents use case scenarios specifically devised for these sites, categorized by their respective business scenarios and groups.

Additionally, D1.2 aims to offer a clear and comprehensive definition and design of the Access Framework Architecture at both the component and sub-component levels. This design is based on the identified requirements, business scenarios, and technical use cases. The report introduces functional descriptions for each component, outlining the fundamental capabilities of the Access platform. The architectural description includes information about the identification of primary system components, their interactions, and the definition of their external interfaces. Each element of the AccesS framework is described in detail, covering numerous functional and technical requirements. Additionally, the report provides a comprehensive overview of the AccesS system design, ensuring that all aspects of the system are meticulously detailed and clearly defined.

1.2 Structure of the deliverable

This report outlines the step-by-step processes used to identify pilot conditions and define the technical specifications, functionalities, and features of the AccesS system architecture, including its various components and sub-components. To ensure comprehensive coverage of these foundational aspects, the report is organized as follows:

- **Chapter 2** presents the methodology employed to design and document the established architecture. It details all the design aspects that were analyzed and adopted in presenting the AccesS system architecture.
- **Chapter 3** describes all the pilot cases involved in the project.
- **Chapter 4** outlines the AccesS business scenarios, which were developed to respond to the market needs and challenges identified.
- **Chapter 5** presents the system requirements, both functional and non-functional, as derived from the consortium's collaborative efforts.
- **Chapter 6** outlines the conceptual architecture, presenting a broad view of the AccesS system and its core components within the architectural layers. This chapter delivers an overview of these fundamental elements at a high level.
- **Chapter 7** describes the Functional View, outlining the specifications for each component, their functions, and their interconnections.
- **Chapter 8** details the Deployment View, offering insights into the physical systems needed to deploy each component. It includes an overview of hardware requirements, specifying

the deployment setup, necessary physical components, dependencies, hardware specifications, and any physical constraints.

- **Chapter 9** introduces the Information View, detailing how information is managed, stored, and distributed within the system.
- **Chapter 10** presents the Dynamic View through Technical Use Cases. It documents the basic requirements and sequence diagrams for each use case to clarify how the AccessS platform operates and which components are involved in performing various tasks.
- **Chapter 11** summarizes the key conclusions and insights of this deliverable and outlines the next steps for upcoming development activities.

1.3 Relation to Other Tasks and Deliverables

This task represents the core technical activity within WP1, taking into consideration results from T1.1, and closely integrating inputs from T1.2 to define the project's technical components, system architecture, and key functionalities of the project. These inputs provide valuable information, such as user requirements, technology assessments, and constraints, which T1.3 then converts into actionable technical solutions. This ensures that the project's technical design and development are aligned with the identified needs and goals, the system architecture is well-defined and that all components-ranging from software module to user interfaces-are harmonized and able to interact effectively.

This deliverable serves as the technical foundation for the AccessS software architecture and development framework, laying out the blueprint for how the system will function, interact, and evolve. This detailed framework is not only crucial for the internal development of the project but also acts as a reference for the activities in other WPs, such as WP4, WP5, WP7, and WP8, providing also insights for the definition of the project's evaluation framework (T1.4).

2 Software Architecture Design Methodology

2.1 Theoretical Background

A software architecture describes the structure and design of a system, focusing on how its components are organized, connected, and interact to achieve their intended objectives. It defines the system's essential features, including its elements, their relationships, and the principles that influence its design and evolution [1]. Architecture also considers the system's environment, ensuring the components work cohesively within their broader context to meet the system's goals and stakeholders requirements and needs. To help create and analyze architectures, an architecture framework is adopted and used [2]. This framework provides a set of rules, principles, and practices to define and interpret architectural descriptions in a consistent way. A core element of architectural frameworks is the use of viewpoints, which define the conventions for creating and interpreting views. Views represent specific aspects of a system, addressing particular stakeholder concerns and organizing information to highlight key relationships and elements. In essence, a view provides a perspective on the system, while a viewpoint establishes the rules and guidelines for constructing and analyzing that view.

Several system architecture frameworks provide structured approaches to system design. Kruchten's 4+1 View Model organizes architecture into five viewpoints: logical, development, process, physical, and scenario, focusing on how these views interconnect to ensure a clear and effective design [3]. The Zachman Framework (ZF) [4], commonly used in Enterprise Architecture, structures system perspectives across key dimensions like data, processes, locations, people, timing, and motivations, enabling a holistic design approach. Similarly, the Open Group Architecture Framework (TOGAF) offers a flexible methodology for enterprise-level architecture development through its Architecture Development Method (ADM), which encompasses iterative phases like visioning, business and technical architecture design, and change management. TOGAF emphasizes adaptability to project-specific requirements while maintaining a structured approach [5].

For defense-specific needs, the Department of Defense Architecture Framework (DoDAF) delivers tailored guidance on architecture content and objectives [6]. Using the Core Architecture Data Model (CADM), it defines operational, system, and technical views, facilitating traceability of requirements and design decisions. In contrast, some methodologies adhere to the ISO/IEC/IEEE 42010 standard without employing a separate framework.

Despite the variety of viewpoint catalogs, many frameworks face limitations when applied to large-scale information systems. To address this, the Rozanski & Woods model expands on Kruchten's "4+1" model, introducing six core perspectives: Functional, Information, Concurrency, Development, Deployment, and Operational [7].

Moreover, some authors advocate for predefined set of views, such as the Rational Unified Process (RUP), based on Kruchten's "4+1" model for software design, or the Siemens Four Views model [8]. However, it is increasingly recognized that architects should adapt views to the specific needs of the system. The Views and Beyond (V&B) approach supports this by promoting the creation of views that are specifically relevant to the system at hand [9].

2.2 Architecture Design Methodology

The architecture design followed a dual approach that combined bottom-up and top-down methodologies. Initially, detailed outlines of key technologies and software components were created, providing a clear understanding of the essential elements that would constitute the Access Suite. Once the individual components were identified, their roles and interactions were analyzed within the context of various business scenarios to ensure alignment with the project objectives. Subsequently, these individual components were integrated into a larger system design, ensuring that the overall architecture was aligned with the project's broader goals and objectives.

2.2.1 Combined Bottom-Up and Top-Down Approach

2.2.1.1 Bottom-up Process

The architecture development began with a bottom-up approach, focusing on identifying all the digital tools that would be developed by the partners and integrated into the Access Suite, as described in DoA. To gain a comprehensive understanding of the functionalities and system requirements of each tool, partners were asked to complete a set of templates. These templates gathered information about their existing solutions, as well as their initial plans and how their tools would integrate into the overall architecture.

At the same time, Business Scenarios and Use Cases were identified as part of Task T1.2. Partners, were again asked to complete templates, but this time outlining how they envisioned their tools being applied within different business scenarios. This step helped clarify how each tool would function in varying contexts, providing a clearer understanding of how the individual components would work together and refining the overall system design.

2.2.1.2 Top-down Process

Once the individual components and technologies were identified through the bottom-up process, the next phase focused on fitting these elements into a larger system design for the Access Suite platform. The goal of the top-down process was to ensure that both the individual components and the system were optimized and aligned with the project's objectives. This phase involved analyzing how the components would interact within the broader system, ensuring that the platform as a whole would function efficiently and effectively. As a result, the overall conceptual architecture of the Access Suite platform was defined.

2.3 System Requirements

To address all the functionalities of the digital tools, both functional and non-functional, a template was shared with all involved partners. This template was created to help establish a standardized, trackable, and prioritized set of requirements. System requirements are essential to the architecture design process. Functional requirements specifically outline what the system should accomplish, including the capabilities it should provide, as well as how inputs are processed to produce outputs. Non-functional requirements, on the other hand, define the criteria for assessing system functionalities and describe the quality characteristics of digital tools.

It's important to define both functional and non-functional requirements explicitly, in a clear and descriptive manner, to align with the project objectives. Requirements should be testable, consistent, explicit and reasonable; and should always consider the respective actors. The format of the template that was shared among the partners aims to capture the essential information about each tool, including

its role, functionalities, connections, and requirements. This approach assisted in defining the overall architecture, dependencies, and integration points, ensuring an efficient development process.

Table 1. Requirements Documentation Format

Name of new tool/component/service/method	
Description and Functionalities	<Describe the role and main functionalities>
Connections/Dependencies/Interfaces	<Provide the connections in relation to other project's components>
Functional Requirements	<Describe the anticipated functional requirements of the tool>
Non-Functional Requirements	<Describe the anticipated non-functional requirements of the tool>
Relevant Use Case(s)	<Specify the use case(s) where the tool will be utilized>
Input Parameters	<Provide a list of the input parameters/data>
Output Parameters	<Provide a list of the output parameters/data>

2.4 Viewpoints

The design of AccessS architecture is a critical part of system architecture, addressing both functional and non-functional concerns. To ensure a comprehensive and well-rounded design, it's essential to analyze the system from multiple perspectives. This approach draws from **Kruchten's 4+1 View Model**, with slight adjustments to better suit its unique needs. This model provides a framework for evaluating the system from 4 distinct perspectives, each focusing on a specific aspect of the architecture:

- **Functional View:** This viewpoint emphasizes how the system achieves its main goals by showcasing its main features and components. It identifies the key components of the system and how they work together, making sure the architecture takes into consideration the business needs. For each digital tool, the respective functional diagram addresses highlighting the sub-components that it consists of, along with the inputs and interactions with the other digital tools.
- **Information View:** The focus here is on the flow and management of data within the system. It defines how information is handled, processed, and transferred between components, ensuring that data integrity and security are maintained across all processes.
- **Deployment View:** This view explains how the system components are distributed across physical hardware. It addresses concerns related to the system's scalability, resource allocation, and the hardware required to support the software.
- **Dynamic View:** This viewpoint illustrates the system's behavior over time, capturing how the components interact and evolve during runtime. It emphasizes system performance, real-time

operations, and how the system adapts to changing conditions or inputs. To represent this, sequence diagrams will be used for each business scenario.

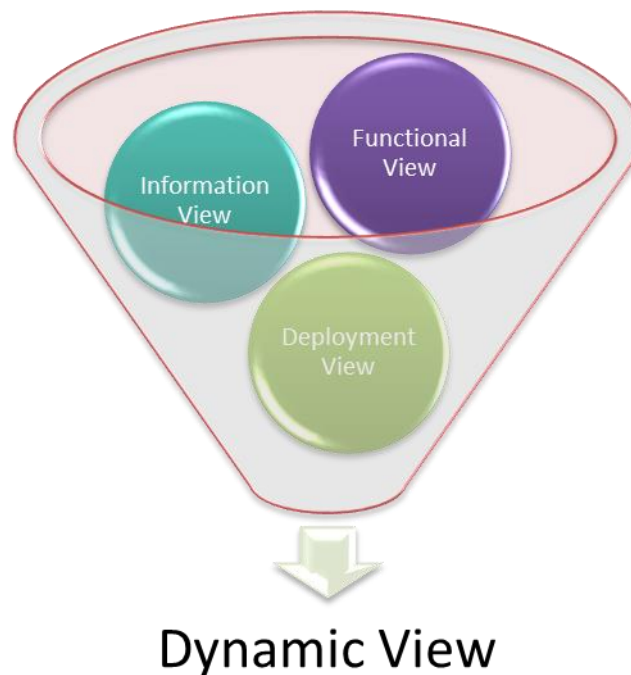


Figure 1. View model of architecture

2.4.1 Functional View

The functional View of the system provides a detailed perspective on the architectural components for delivering the system's core functionality. In this viewpoint, each component is represented as a functional element, categorized by its specific responsibilities and interactions with other elements. This organization helps clarify how various components work together to achieve the system's overall purpose.

As one of the key architectural viewpoints, the Functional View plays a critical role in capturing the system's structure and intended behavior. It illustrates the relationships and dependencies among components, helping the partners to understand how data flows and processes are managed within the system. This viewpoint not only highlights what each component is designed to perform, but also how it interacts with other components to achieve both functional and non-functional objectives.

In general, a component diagram includes a description of an individual component and the integrated sub-components, as well as a representation of the dependencies between components. An example of a component diagram is shown in the following figure.

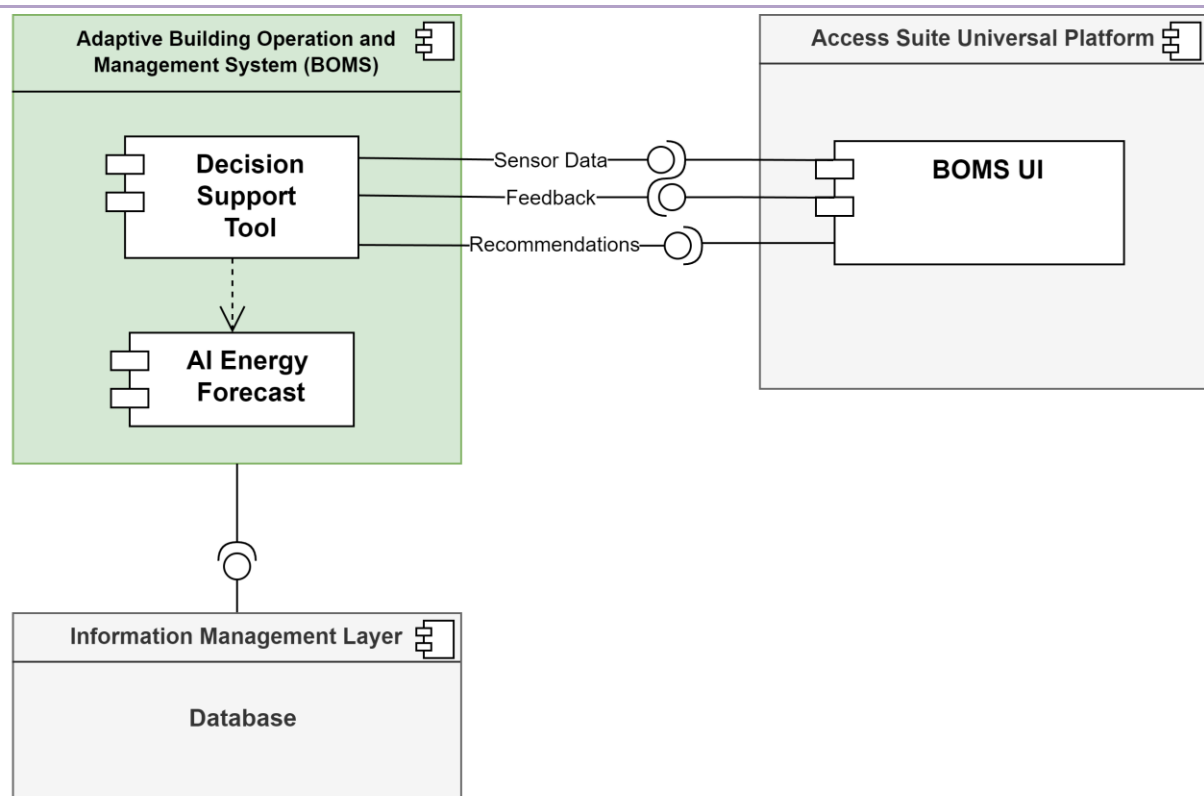


Figure 2. Example of BOMS component diagram

The component diagram is a structural UML diagram used to illustrate how the system’s components and actors are organized and interact. The diagram often includes several standard symbols and shapes to represent these components, their interfaces, and the relationships between them. The table below provides a more detailed explanation of various symbols and shapes.

Table 2 Component Diagram Definitions

Symbol	Description	Example in Diagram
Component	Represents a modular part of a system that performs a specific task or function. Designed as a rectangle with smaller rectangles (interfaces) on the sides.	The “Adaptive Building Operation and Management System (BOMS)” is shown as a large rectangle enclosing other components like the Decision Support Tool.
Interface	A specification of a set of operations that can be performed by a component. It allows components to communicate with each other. Displayed as a small circle or a lollipop icon.	The circles on the left of the "Decision Support Tool" represent interfaces for sensor data, feedback, and recommendations.

Dependency	Indicates that one component relies on another. Represented by a dashed arrow pointing from the dependent component to the component it depends on.	The dashed arrow pointing from the "Decision Support Tool" to the "AI Energy Forecast" shows that the Decision Support Tool depends on the generated forecasts from the AI Energy Forecast tool.
Data Flow/Connector	Represents the transfer of information or data between components or interfaces. It is displayed as a solid line.	Lines between components like "Sensor Data," "Feedback," and "Recommendations" show the flow of information.

Figure 3. Symbols and Shapes in Component Diagrams

2.4.2 Information View

The Information View provides a comprehensive yet abstract perspective on how information flows between the different components of a system. Its purpose is to document how data is managed, stored, and distributed across the system. It seeks to provide a consistent and clear understanding of the lifecycles of the information objects handled by the system. The primary goal is to address significant issues with the structure, content, ownership, and transfer of data inside the infrastructure.

A thorough data model will be created to identify the many types, formats, and relationships of data transferred inside the system, particularly in the AccesS project, where multiple diverse sensors are going to be installed. This model will structure data flow between components while also ensuring consistency by defining semantic relationships between data elements. To facilitate integration and interoperability, all partners will use the same standardized data format, allowing for easy exchanges and preventing differences in data processing throughout the system.

2.4.3 Deployment View

The Deployment View describes the physical environment in which the system will be built, as well as the dependencies that exist inside that environment. It describes (i) the hardware and software infrastructure that supports the system, such as general-purpose hardware for core functionalities, database storage systems, user access hardware, and network components that ensure specific quality attributes such as security via firewalls; (ii) the technical requirements of the environment, such as the operating systems that run on the devices; and (iii) the mapping of system components to the runtime environment. Within AccesS project, deployment diagrams are used to capture this information.

2.4.4 Dynamic View

The Dynamic View offers insights into how the system operates in its runtime environment, showing how it responds to external or internal signals. It highlights interactions between the system's actors and components, often represented as data flows that indicate information exchanged during parallel or sequential execution of tasks. All these interactions are depicted using sequence diagrams, which are derived from specific use cases. A sequence diagram is a tool to visualize these interactions in a time-ordered sequence. It shows how messages are passed between actors and system components during the execution of a use case. The sequence diagram outlines the order in which these actions

occur, making it easy to understand the flow of events and how different parts of the system work together.

To ensure that all the necessary details are captured, a template that is presented in Table 3, was developed to highlight the key elements of each technical use case. These use cases serve as a blueprint, guiding each business scenario toward its full potential. In Section 10 the business scenarios are based on these use cases. The methodology applied to the definition of the next use cases is **based on IEC62559**. A **use case** is a detailed description of how users (actors) interact with a system to achieve a specific goal. It outlines the steps involved, the conditions under which the interaction occurs, and the expected outcomes.

Actors: They are the individuals or entities that interact with the system in a use case. They can be:

- **Primary Actors:** The main users who initiate and benefit from the use case (e.g., building managers, end-users).
- **Secondary Actors:** Entities that support or are affected by the use case but are not the main initiators (e.g., maintenance personnel, energy providers).

System: Involves the technology or platform that facilitates the interactions described in the use case. This can include hardware, software, and integrated solutions that perform specific functions to achieve the goals of the use case.

Table 3. Use Case Documentation Format

Use Case #	Unique ID
Use Case Name	A very specific name that aids to easily understand the scope of the UC
Intent	Brief description of the purpose of the use case
Version/ Author	Version of the application scenario / Who documented the use case
Actors Involved	Actors involved in the use case, e.g., Building professionals, Engineers, Tenants/Owners, Facility Managers, Public Bodies, Researchers/ Academics, Software tool Developers, ESCOs etc.
Brief Description	Description of the series of steps for the defined use case in a clear concise manner. The description will include what the system shall do for the involved actor to achieve a particular goal.
Pre-conditions	A list of assets which are needed specifically for this use case. (e.g., BIM/ ifc file, real time data etc.)
Trigger	The action that starts the use case
Goal (Successful End Condition)	The ultimate aim and end condition(s) of the Use Case upon successful completion

Post Conditions	The effects of this UC to the overall state of the system or of its core architectural elements.
Related Use Cases	e.g., U.C.1.2

3 Pilot Study Analysis

AccessS project includes six pilot sites and buildings, namely the Christo and Jeanne-Claude Center in Gabrovo, Bulgaria, the Brancacci Chapel in Folrence, Italy; the Droom je Thuis Doundation in Naaldwijk, Netherlands; Casa Girasole in Massagno, Switzerland and the Palazzo di Citta in Bari, Italy. The pilot sites have been carefully selected from project conceptualisation, trying to address numerous types of uses and real-life situations and challenges in accessibility that people face under common use case scenarios in order to maximize project's impact for end-users with disabilities and older people. The different AccessS pilot sites are described in more details in the following sections.

3.1 The Christo and Jeanne-Claude Center, Gabrovo, Bulgaria

Gabrovo is located in the North Central Region of Bulgaria along Yantra River, with a total population of around 48133 urban inhabitants and a covered area of around 25 km².

In 2013 the city joined the Covenant of Mayors with a long-term vision to be “Green, Innovative and Smart”. The future development of the city aims to include the construction of sustainable and inclusive urban infrastructure, the establishment of a sustainable and inclusive mobility scheme at the urban level, the use of renewable energy sources and the enhancement of knowledge and skills via dedicated training. An important document for the municipality is the Integrated Development Plan (IDP) where a list of innovative solutions for smart cities are set based on integrated territorial investments.

The Municipality of Gabrovo submitted during the second week of February 2025 a separate project proposal for the Christo and Jeanne-Claude Center building, as part of the already approved Integrated Territorial Investment concept. This submission included a detailed description of the individual functional spaces and a comprehensive financial analysis. From this date, a three-month review period will follow, allowing for project approval and potential adjustments.

3.1.1 Description of the pilot site

The Christo and Jeanne-Claude Center, which was a former vocational textile high-school, will become an exhibition center featuring the work of Christo and Jeanne-Claude, a documentary exhibition on the history of the Yavashev family and Cristo's childhood. The area is included in the Gabrovo IDP and also the surrounding riverside area is planned to be reconstructed within the integrated territorial investment.

Amendments to the Detailed Development Plan (DDP) are expected to be finalized by 2025, allowing construction works to start by mid-2026.



Figure 4 The Christo and Jeanne-Claude Center entrance

Indeed, the Gabrovo IDP includes the redevelopment of the riverbank area of the Yantra river. With a total area of around 7.5 hectares in the north of Gabrovo's city center, it covers both the banks of the river, including riverbends, retaining walls and infrastructure, and iconic public buildings in the inter-neighbourhood spaces. The area can be divided as follows:

- Right bank zone (east): includes neighborhoods and streets per the current Master Plan of the Central Eastern Urban Area. It includes sport complexes, hypermarket, parking spaces, attractions and parks,
- Left bank zone (west): includes other parts of residential neighbourhoods and streets per the current Master Plan of the Central Western Urban Area, the House of Humor, *the former textile school buildings*, garages and parks.

Other types of buildings that are present in the area are production facilities, public service buildings as education, trade, culture, sports and healthcare. The adjacent Bryanska and Orlovska streets are main communication routes along the city's length, and the bridges at the southern and northern ends facilitate short cross-connections.

Although some improvements were made, such as around the Sports Hall and the House of Humor, much of the riverbank remains neglected. This includes insufficient landscaping, damaged pavement, and limited recreational facilities. Unkempt vegetation and abandoned plots dominate, presenting an unappealing view to both the river and the buildings adjacent to it.

Therefore, the renovation project proposes the creation of interconnected and multifunctional open public spaces at different levels, and it is divided into 5 development zones for phased implementation:

- **Zone A (eastern bank, south):** Sports Hall area, from the Padalski Bridge to the Billa property. The renovation for this area includes retaining and upgrading of the southern plaza with granite paving, creating cantilevered pedestrian and cycling paths over the retaining wall along the river, adding recreational areas, including a children's playground with safety flooring and the optimization of parking and additional landscaped buffers.

- **Zone B (eastern bank, north):** – Residential area near northern Billa. The project here is to extend the riverside paths with green buffers, build playgrounds, sports areas, and shaded rest spots, enhance parking and add underground waste containers.
- **Zone C (western bank, south):** House of Humor area. The rear courtyard is planned to be transformed into an open public space. Terraces and step-seating will be added for events and exhibitions and multi-level retaining walls will be built with greenery.
- **Zone D (western bank, north):** Designated for extreme sports park for bicycles and skateboards, with asphalt and concrete surfaces.
- **Zone E:** New pedestrian and cycling bridge connecting public spaces on both banks, with artistic and functional design.

The pilot building is located in Quarter 111, Lot II in Central Gabrovo City, with a total land area is 13,856 m². The complex consists of multiple structures with distinct functions described in the following:

- Main building (Body 1): with an area equal to 2217 m², it might mainly be used for classrooms, administrative offices and common spaces,
- Secondary building (Body 2): it extends for 396 m² and its potential uses are for laboratories or auxiliary spaces,
- Connecting area (Body 3): area to connect Body 1 and 2, of approx. 122 m²,
- Other buildings that are mainly for storage and production (9 to 486 m²) and energy production (9 m²), represented by Body 4 to 10 in the Figure 6 Cadastral map of Lot II Figure 6.



Figure 5. Rendering of the future Yantra river area

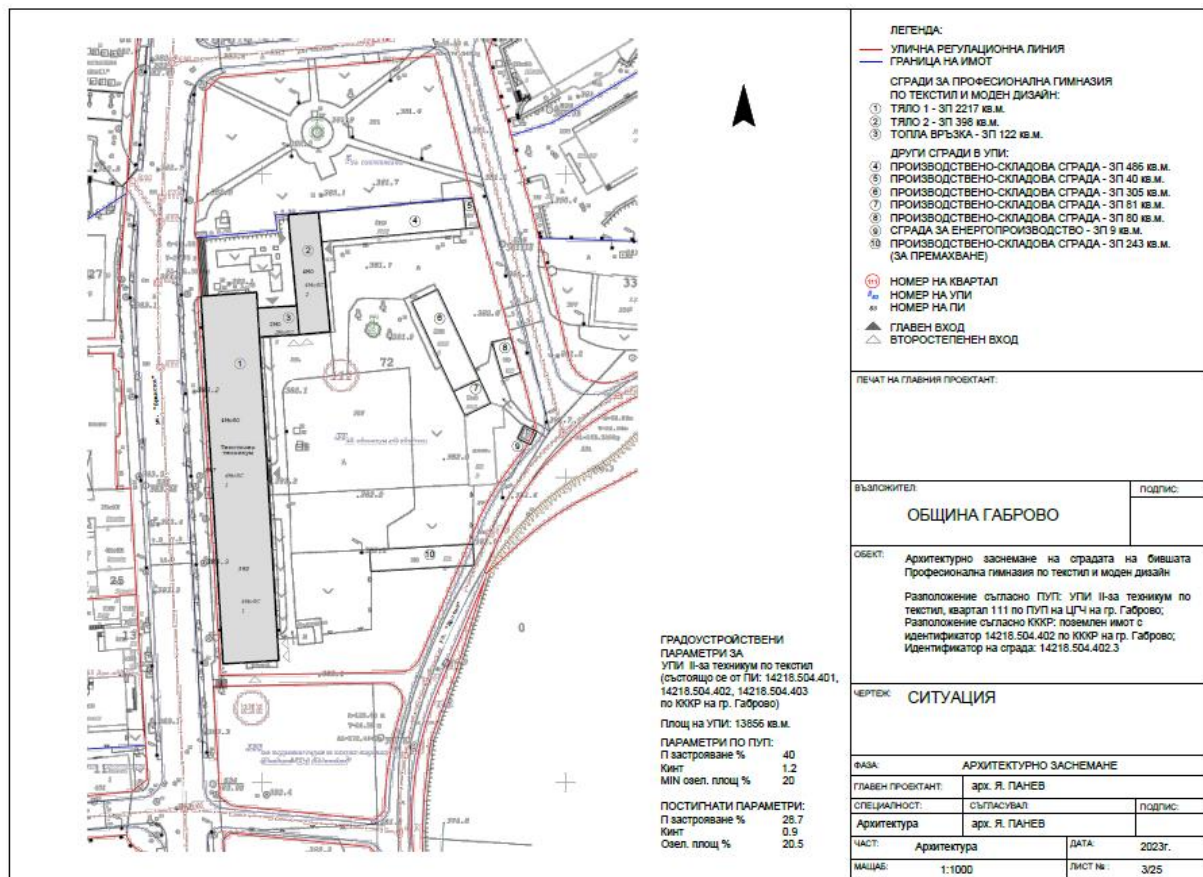


Figure 6 Cadastral map of Lot II

Despite the fact that the building is currently not operational, in the last years several events with citizenship have been organized. The events were mainly for artistic and musical purposes but also to present the future renovation plans and an Architectural competition for the future shape of the building and surrounding areas. Some examples of the events organized are workshop with artists and citizens, visits by scholars and guided tours for a total of around 50.000 visitors in 2023 and around 47.000 visitors in 2024. The type of users visiting the Center varies significantly, from pupils and university students to adults, events attendees and Gabrovo's guests. With particular reference to the objectives of AccesS, the disabled users that visited the Center in 2024 are 922 so far. Nonetheless, it should be taken into account that the Center is not operational yet then at the current state, it is not possible to have precise details on the number and types of disabled visitors. A demographic analysis is ongoing to gather information on the type and numbers of potential users of the museum and will be finalized in the subsequent phases of the Renovation Plan. In order to properly address needs and requirements of disabled peoples and ensure that they can have access granted to public buildings and spaces, stakeholders such as Association "Future and Protection for Persons with Intellectual Disabilities", Foundation "Care for children with disabilities" and Union of the Blind in Bulgaria will be involved in the preliminary design of the demonstrator.

3.1.2 Analysis of needs and requirements

The Gabrovo IDP is an important and impactful project with significant budget and several smart cities solutions, and particularly interests the Christo and Jeanne-Claude Center, in terms of planned interventions, timeplan and the impossibility to install sensors to monitor environmental parameters. The museum is currently not operational, thus there is no electricity or energy consumed or visitors on site.

The Renovation project envisions the transformation of the riverside zone through the reshaping of the riverbed area and modelling of the banks, renovating and creating a pedestrian path with resting areas, creating zones for sports, recreation and outdoor cultural activities. Moreover, the project plans as well to refurbish or renew existing or new mobility routes and parking areas and improve in general the green areas around the river. In particular, the already existing pedestrian and bike routes along Avram Gachev St. and Dunav St. will be enlarged to link the entire zone on both banks of the river. The project should take into account the Gabrovo Municipality's strategic development plans and safety and regulation policies related to the coastal infrastructure of the river while offering new attractions and socialization opportunities. Moreover, the project includes smart solutions as modern and energy efficient street and parking lighting and video surveillance, with the aim to modernize architectural-spatial solutions with modern urban design elements, new materials and technologies.

With particular respect to accessibility and urban mobility, the municipality of Gabrovo has many needs related to both the pilot building and the surrounding area. One of their most important needs is specifically related to install accessibility solutions as ramps, handrails and accessible pathways. Moreover, public spaces and seating areas require improvements for the elderly and disabled population in particular. About mobility, there is insufficient transportation for connections to major urban centers like Sofia and Plovdiv, thus impacting on regional, national and international access. Looking at the urban level and in particular around the center of the city, the mobility scheme lacks specific amenities for accessibility (i.e. accessible transport stops, accessible pedestrian paths etc.). An additional problem around the topic is a general lack of consistent educational projects on inclusivity and inclusive mobility for both decision-makers and general public. This might be partially due to missing funding for accessibility-related projects.

In 2025, the actual pre-design of the Renovation plan, which includes as well energy audits and evaluation, will end. Subsequently, the design and funding phases will begin, providing a profound opportunity to capitalize on the AccesS digital solutions for the actual design of an inclusive and accessible built environment, taking into account that the actual renovation works on the Christo and Jeanne-Claude center will start around 2026 until 2028. In the future, there will be conducted demographic analyses to complement the information from literature on type of users and in particular on the disability types, to be considered in the scope of the AccesS project. On the technical perspective, the installation of photovoltaic panels for the Center is under discussion, and the implementation and development of a Building Information Model (BIM) for the building is planned.

Through Access, accessibility and inclusivity will be evaluated and tested in the under-design facilities, including new solutions for e-mobility in urban planning in the riverside zone surrounding the Center. The municipality plans to invest 20M € for the renovation and equipment of the building and additional 5M € for the riverside recreation zone, constituting a great opportunity to follow the design and operation principles and guidelines that will arise from the project.

Project Timeline Overview

The renovation of the Christo and Jeanne-Claude Center follows a clearly defined timeline to ensure project milestones align with Gabrovo's Integrated Development Plan (IDP). Below are key stages of development, highlighting preparatory work, design, construction, and operational launch.

1. Preparatory Phase (2024 - 2025)

- **June 2024 - January 2025:** Completion of the General Development Plan (GDP) discussion and approval process.
- **January 2025 - March 2025:** Conducting essential studies including energy audits, geodetic surveys, and demographic analysis.

- **December 2024 - March 2025:** Finalization of the architectural competition terms of reference and pre-competition consultations.

2. Architectural Competition (2025)

- **April - May 2025:** Launch and execution of the architectural competition.
- **June 2025:** Evaluation of submissions, jury selection, and announcement of the winner.
- **July - September 2025:** Contract negotiations and signing with the winning design team.

3. Design and Approvals (2025 - 2026)

- **October 2025 - April 2026:** Development of the technical and working design projects.
- **May - June 2026:** Regulatory reviews, public consultations, and submission for building permits.

4. Construction Phase (2026 - 2028)

- **July 2026 - December 2028:** Start of construction and site development.
 - **Mid-2027:** Completion of the structural and architectural elements.
 - **Early 2028:** Final interior works, installation of technological systems, and landscaping.

5. Launch and Operational Start (2028 - 2029)

- **January - March 2029:** Installation of equipment, functional testing, and staff training.
- **April 2029:** Inauguration of the Christo and Jeanne-Claude Center.

3.2 The Brancacci Chapel, Florence, Italy

Florence is the capital city of the Tuscany region in Italy. It is also the most populated city in Tuscany, with 366.033 inhabitants (November 2024), and 990.527 in its metropolitan area. Florence city center was declared an UNESCO site in 1982. It has a historical plant with narrow streets, pavements in cobblestone, heritage buildings that worth preserving and its architectural constraints must be considered in urban regeneration planning. The first UNESCO Management Plan was approved in 2006, and last update is in 2022.

Florence strategic planning has adopted an interdisciplinary and integrated holistic approach, by enhancing synergies, empowering stakeholders, and involving citizens to face the key challenges. This resulted in the approval of several shared strategies, leading city's action. The Smart City Plan [9] offered a coordinated vision of urban life from an integrated planning perspective in terms of infrastructures and mobility, energy efficiency and environmental sustainability, focusing on social dimensions and citizens' well-being. A tool for achieving concrete goals for the city and the community, thanks to solutions for improving everyone's life quality, it is a holistic path at 2050 developed through a participatory process based on system thinking methodology. Florence set up the Smart City Control Room (SCCR) to support decision-making, planning and timely monitoring of interventions and strategies, thanks also to the H2020 REPLICATE project [10].

Florence is also committed to tackling the issue of sustainability with the approval in 2023 of the Sustainable Energy and Climate Action Plan [11] and the Green City Accord (GCA). Moreover, Florence has been selected for the EU Mission 100 Climate-neutral and smart cities to be a zero-emission city at 2030. submitted the Climate City Contract (CCC) [12] in 2023, approved by the EU in 2024.

Finally, the Adaptation Plan for buildings and public spaces (it is about roads, pavements, car parks, gardens, housing, museums, libraries, sport facilities, etc.) is updated every year to guarantee a continuous progress to improve accessibility.

Florence is also committed to ensuring accessibility for all visitors, offering a range of services and tours tailored for individuals with disabilities. FeelFlorence [13] is a mobile app and a website connected to a Content Management System and a BigData platform that suggests unusual itineraries in the city, in the neighbourhoods and in the metropolitan area, to bring tourists closer to local experiences. Through real-time detection of the presences in the city and predictive analysis, this tool provides alert notifications on the most congested areas allowing tourists to avoid overcrowded destinations, stay updated on events and initiatives and better organize their stay and their visit schedule. FeelFlorence also includes a specific session devoted to “accessible Florence” with subjects such as mobility, accommodation and places to visit. In the same section, it’s possible to find suggestions from museums dealing with all kinds of disability, from visual and hearing impairments to intellectual disabilities.

Several attractions offer free admission for individuals with disabilities and their companions, and most civic museums have implemented ad-hoc services to support the accessibility and inclusivity of disabled people, including sensory and tactile paths.

On the mobility perspective, the Sustainable Urban Mobility Plan (SUMP) approved in 2021 is the strategic plan that aims to guide sustainable mobility policies in the Florence Metropolitan Area. The plan addresses the challenges related to urban mobility in a more sustainable and integrated manner. The Sustainable Urban Logistic Plan (SULP) [14] is linked to SUMP but focussed on logistic sector. Lastly, the APP Infomobility Florence (IF) provides information on city mobility in real time, with the possibility also to be tailored to the user’s need (for example, setting preferably using public transport, with fewer CO₂ emissions, etc.).

3.2.1 Description of the pilot site

The Brancacci Chapel, located within the boundaries of the Florence UNESCO area into the Church of Santa Maria del Carmine. The church and the chapel are treated as separate places to visit and as such have different opening times. The Brancacci chapel is a civic museum already part of a wider project called Brancacci Project [15]. It is a collaborative initiative aimed at the preservation and enhancement of the chapel’s frescoes for diagnostics, monitoring and valorisation of the significant artworks. The project is led by the Institute of Heritage Science (IPC) of the National Research Council (CNR), in partnership with the Municipality of Florence, the Superintendence of Archaeology, Fine Arts and Landscape for the metropolitan city of Florence and the provinces of Pistoia and Prato, the Opificio delle Pietre Dure Institute. The project is made possible through the financial contributions of Friends of Florence and the Jay Pritzker Foundation, underscoring the importance of collaborative efforts in cultural heritage preservation.

The Brancacci Chapel, located within the Church of Santa Maria del Carmine in Florence, is renowned for its exceptional frescoes by Masaccio, Masolino, and Filippino Lippi, marking a pivotal moment in Early Renaissance art. After a two-year diagnostic and restoration project, the chapel reopened to the public on May 2024. Founded in 1268 by Carmelite friars from Pisa, the Church of Santa Maria del Carmine was constructed with contributions from the municipality and prominent Florentine families. The church was consecrated in 1422, with construction completing in 1475. Notably, the facade remains unfinished, showcasing a raw stone and brick exterior.



Figure 7. External view of the Church of Santa Maria del Carmine

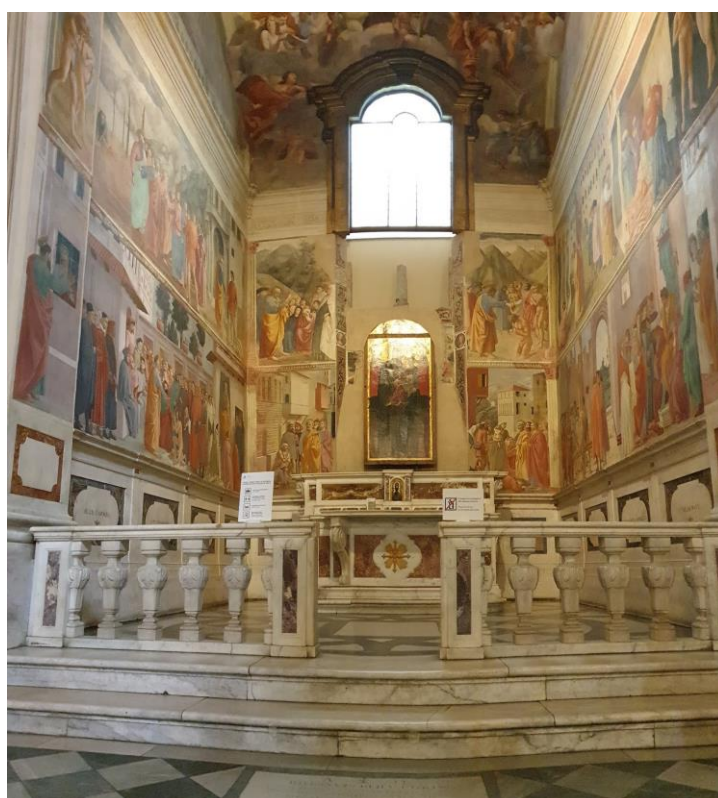


Figure 8. Detail of the inside of the Brancacci chapel

As part of the Brancacci Project, the chapel underwent diagnostic tests in November 2020 in the so-called Brancacci Project Diagnostic [16]. The project revealed some deterioration of the fresco cycle that called for restoration. In 2021, the diagnostic and valorisation project dedicated to the Brancacci Chapel began, carrying out in-depth investigations on the causes of deterioration, but also on the executive techniques of the work.

During the presence of the diagnostic restoration site inside the Brancacci Chapel and following the idea of an “open museum”, to enjoy differently the museum, it has been developed the idea to access and visit the chapel through the site infrastructures already in place (elevator included) for small groups and by reservation taking knowledge at the same time about frescos and its maintenance. For the first time in the city, a construction site has been made accessible to disabled visitors.



Figure 9. Visitors during the renovation works at the Brancacci chapel

The diagnostic techniques employed in the first part of the renovation works included infrared thermographic analysis, Fourier-transform Infrared Spectroscopy (FT-IR), portable x-ray fluorescence (XRF) and fiber optic reflectance spectroscopy (FORS) and high-definition multispectral imaging, including UV and raking light. The diagnostic methods were non-destructive and portable, thus allowing for a deep understanding of the frescoes' conditions while keeping them intact. The information collected on materials composition, structural integrity and areas affected by environmental factors is used as a guide for targeted current and future conservation efforts. Through this multidisciplinary approach, the Brancacci Project aims to ensure the long-term preservation and appreciation of the chapel's invaluable frescoes, integrating advanced scientific techniques with cultural heritage conservation. The results of the diagnostic were also published in a study titled "Non-Destructive Diagnosis on the Masaccio Frescoes at the Brancacci Chapel, Church of Santa Maria del Carmine (Florence)" [17]. This research underscores the importance of integrating advanced diagnostic tools in the preservation of cultural heritage, ensuring that interventions are both effective and minimally invasive.

From 2021 to 2023, the Digital Heritage Innovation Lab (DHILab), part of the Italian's CNR, run the Brancacci VR project [18], an initiative to reconstruct the chapel digitally to offer immersive

experiences to enhance public engagement and putting emphasis on the importance of this cultural heritage site. The project enables users to virtually explore the chapel, providing detailed views of the frescoes and architectural elements. This approach allows for a deeper appreciation of the artworks' context and details that may be challenging to observe during physical visits. Utilizing the open-source framework Aton, developed by CNR, the platform facilitates collaborative exploration. Users can share insights and discuss the narratives depicted in the frescoes, fostering a communal learning environment. This way, the project makes the Brancacci Chapel accessible to individuals unable to visit in person, thereby broadening the reach of this cultural heritage site. At the same time, it is possible to attract interest in the work of art remotely even from people who do not usually frequent cultural sites. The project is based on photogrammetry and 3D modelling of the chapel, to create accurate digital replicas of the interiors, and integrates them with Virtual Reality to provide an immersive experience via VR headsets and compatible devices remotely. Given the enhanced accessibility, ease of use and availability of the platform, the project can also serve for educational and engaging purposes of a wider public. The Brancacci VR Project exemplifies the integration of digital technologies in cultural heritage, providing innovative ways to experience and study historical artworks. It serves as a model for similar initiatives aiming to preserve and promote access to cultural assets worldwide. The first result of the project was released in 2022 and is the prototype Brancacci Point of View (BrancacciPOV)[19] to offer a hybrid experience where the virtual tour is accompanied by a guide that shares significant points of view with the visitors, allowing for a synchronized and immersive visit to the chapel. Users can engage in tasks and discussions, enhancing their understanding of the chapel's artistic narratives. The platform is accessible via desktop, tablet, smartphone, and Oculus devices, making it versatile for various user preferences. BrancacciPOV serves as a valuable tool for educational purposes, remote guided tours, and as a support for on-site visits, thereby broadening access to this cultural heritage site.

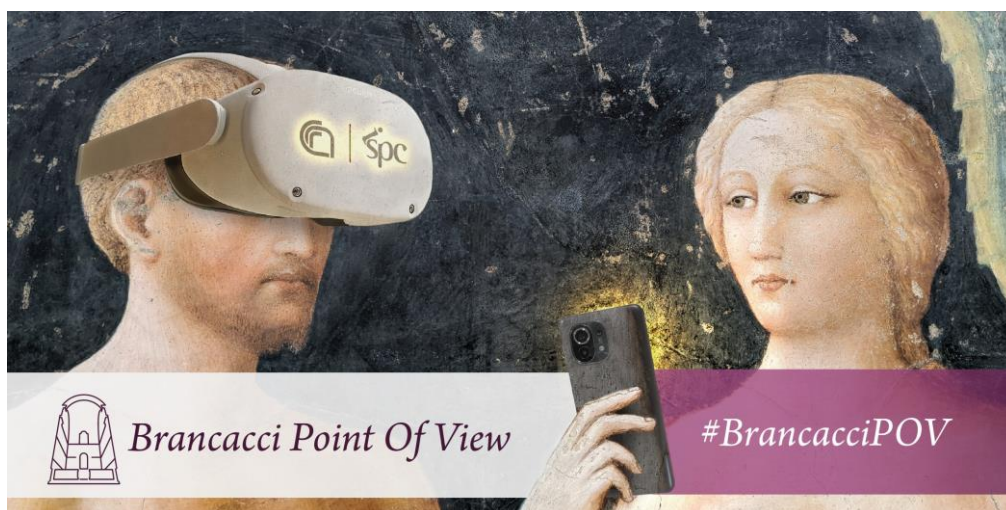


Figure 10. BrancacciPOV poster

3.2.2 Analysis of needs and requirements

The development of the city is strongly constrained by the need of preserving the rich historical and monumental heritage that very often represents a concrete obstacle to the most ambitious projects. As an example, the interventions for energy efficiency and saving must be done in compliance with the landscape constraints and boundaries thus adapting the technology and set of opportunities to the urban context. The regular maintenance restoration works within the chapel, taking place every 2 years, pose some accessibility challenges though giving the unique opportunity to follow the lifecycle of a cultural heritage example.

With particular reference to the AccesS pilot site in Florence, the municipality would like to couple environmental monitoring with the number of visitors to the chapel, considering that a video surveillance system, access and presence control systems are already installed in the chapel. The objective would be to track the number of visitors and the duration of their permanence to ensure a pleasant and stress-free visit to the chapel. Through the monitoring of accesses, it could be possible to avoid overcrowding, which could also damage the chapel and its paintings. Moreover, the Municipality is interested in installing sensors to monitor the conservation status of wall paintings and wall structures with the goal to allow the implementation of virtual inspection. In this regard, the municipality would need to promote awareness on cultural heritage protection and maintenance over time. The 3D models of the chapel available from the Brancacci VR project will be considered whether they can be leveraged from the AccesS tools, while the available 2D/3D drawings will act as the basis to develop the BIM models needed. Moreover, Florence has the interest, as part of the activities carried out in subsequent phases of the AccesS project, on the investigation of ways to enlarge their already running Brancacci VR project with additional functionalities in Virtual and Augmented Reality, to improve and enhance accessibility and inclusivity for a wider public.

In general, the platforms and tools developed must comply with the new Unified Regulation for cloud infrastructures and services for the Public Administration, adopted by the Italian National Cybersecurity Agency (ACN) in 2024 [20]. This regulation establishes comprehensive guidelines for the adoption and management of cloud services within Italy's public sector. The regulation outlines procedures for classifying data and digital services, providing a framework for public administrations to identify appropriate cloud solutions based on the sensitivity and importance of the information involved. It defines the criteria and processes for qualifying cloud services and infrastructures, ensuring they meet specified standards of security, performance, scalability, and portability. Cloud service providers seeking qualification must undergo a digital application process through the ACN's platform. The regulation specifies minimum requirements for security, computational capacity, energy efficiency, and reliability that digital infrastructures must satisfy to support public services effectively. Moreover, it addresses the use of housing infrastructures and proximity services (edge computing), which are increasingly important for reducing latency and enhancing service delivery to end-users. The regulation introduces a monitoring mechanism to ensure continuous compliance with the established standards. In addition, the regulation also affects the public data repository and manages the access to the data stores, which has to be authorized and strictly monitored and anonymised. The AccesS project will acquire and take these policies in consideration when defining strategies to gain access to data stored in public repositories for the Brancacci chapel.

3.3 Droom je Thuis Foundation, Naaldwijk, Netherlands

Naaldwijk is a town in the Dutch province of South Holland with a population of around 15440 people. It is part of the municipality of Westland, and is around 10 km southwest of The Hague. Naaldwijk was previously an independent municipality, with a covered area of around 25 km². Since 2004, the municipality of Naaldwijk was merged with the neighbouring municipalities De Lier, 's-Gravenzande,

Monster and Wieringen and now they form the municipality of Westland, whose actual administrative capital is Naaldwijk.

Stichting Droom Je Thuis is a parent-led initiative that provides a safe and loving home for 12 young adults with intellectual or multiple disabilities. Established in 2012, the foundation aims to create a small-scale, nurturing living environment where care, companionship, and personal attention are paramount.

3.3.1 Description of the pilot site

Located in the heart of Naaldwijk, the Droom Je Thuis house offers residents the opportunity to live independently while ensuring that care and family are always nearby. On April 1, 2023, the residents moved into their new apartments, where they have since felt completely at home. This environment allows them to develop and build friendships, and hold a valuable place in society.



Figure 11. Droom je Thuis Foundation

The building has a gross floor area of approx. 1.255 m² and is divided into three floors. The first and second floors consist of 12 apartments, each designed with a bathroom, bedroom, and kitchenette, with a total area of approximately 45 m² each. The ground floor hosts two living rooms, a kitchen, a utility room, a laundry and drying room, office and staff sleeping area with bathroom, a sensory room, an exercise room, toilets, bicycle and equipment storage and a waste container room, and it has a total area of approx. 200 m².

The house is provided with a washing room and a place that is suitable for parking and charging mostly electric means of transport. The central space on the ground floor can be utilized by the community. The building is equipped with an accessibility system, which allows individuals with disabilities to move to their own homes or living rooms without assistance.

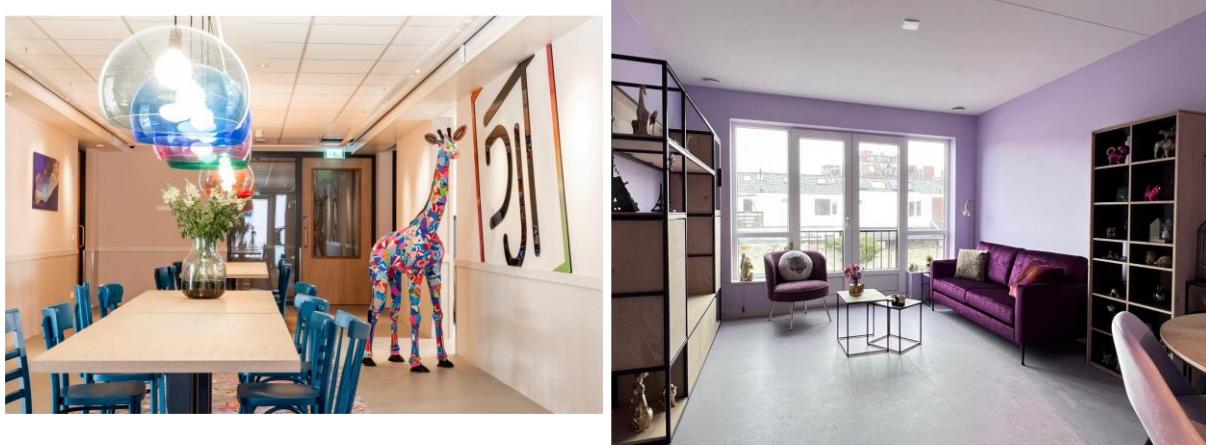


Figure 12. Droom je Thuis Foundation

The building has been designed with a focus on minimal energy consumption and does not rely on gas usage. Indeed, there are 45 PV panels installed with 375 Wp, an Enphase IQ7 converter and two load meters. There are 14 Remeha Eria Tower 11kw heat pumps installed (one heat pump for each apartment, one for ground floor and sensory room to provide heating and hot water), with a Gateway-08 Remeha modbus gateway each. Moreover, there is one air handling unit, Nedair Everyline 4.000, with a UTP interface, and an energy meter on the grid. Floor heating is implemented in all spaces, there are also fire and alarm systems that can be monitored remotely, and data and WiFi network. Access control is implemented via a Salto system and data are stored in a database and dedicated procedures are requested for data access due to privacy concerns. The window blinds and lighting are controlled via a Free@Home system by ABB. Finally, in the buildings there are 8 Airteq sensors for temperature, sound and CO₂ measurements that export data on a weekly basis in CSV format. An IoT system is being developed to automate legionella prevention by controlling the heat pumps and monitoring the temperature fluctuations. All the data monitored in the building, and also the PV energy generation and remote control of smart home appliances can be accessed by dedicated APIs and/or WLAN. The future plans for the building are related to the installation of an EV charging station, most probably within 2025 after an electric van will be purchased, to benefit from flexible energy rates starting from next year via optimized energy usage decisions based on the “day ahead market” schema.



Figure 13. Technical asset on the roof of the building

Regarding accessibility of the building, the doors of facade, living rooms, hallways and 50% of the apartments are equipped with automatic door openers. The Salto access control monitors the facade doors, apartments, technical rooms, office and storage rooms. The doors are threshold-free and there are both stairs and elevator to access the floors. Moreover, depending on the type of disability of the tenant, some apartments are equipped with special ceiling lifts in bathroom and bedroom.



Figure 14. Detail on ceiling lifts installed in a bathroom

All apartments are equipped with a two-way communication care call system, which is able to detect voice call or unusual sounds and alert caregivers. This way, caregivers can listen and talk with the tenants and intervene in case assistance is needed. In some cases, the rooms are equipped with cameras to allow caregivers to monitor activities.

3.3.2 Analysis of needs and requirements

The residents need 24-hour care. This means that care and guidance is always needed during the day and a sleeping shift must be available at night. The residents need help with their personal care, dressing, and household chores. They also need guidance in regulating their behaviour and dealing with different situations. In addition, the residents need support in entering and maintaining social contacts and in carrying out useful activities. The composition of the residents is mixed, in terms of disability, gender, level of functioning, religion, sexual preference, origin or skin colour. The Foundation organizes and provides the care itself, whereby continuity and quality are further guaranteed through cooperation with a professional care provider.

As the building is rather recent, a wide variety of smart sensors and RES are already installed. Hence, the interest of the pilot is to connect PVs, heat pumps, climate control system, weather forecast, EV charging station and energy rates into an integrated system, and coupling with the AccesS Building Operation and Management system (BOMS) will be investigated. 3D models and 2D drawings of the building are available, as well as a navigable 360 model in matterport of the spaces of the building, and will significantly improve the application of the AccesS Use Cases to the pilot. Moreover, one of the most important aspects to be monitored and controlled, according to the pilot's needs, is temperature and the automatic control of heat pumps to prevent legionella automatically. However, with particular reference to this pilot, privacy shall be ensured and data access has to be authorized by curators of the tenants as some of the users have intellectual disabilities.

3.4 Casa Girasole, Massagno, Switzerland

Massagno is a municipality in the district of Lugano in the canton of Ticino in Switzerland with a total population of around 7.000 people.

Casa Girasole is a non-hospital healthcare facility owned entirely by the Municipality of Massagno and operates on a non-profit basis. It accommodates elderly individuals who are no longer able to live independently at home and require care and assistance from professionally qualified staff. In addition to long-term stays, Casa Girasole provides temporary stays for elderly individuals who, for a certain period, lack family assistance or require rehabilitative activities.

The facility, designed by architects Claudio Negrini and Giancarlo Fumasoli, has been operational since September 2002, and is committed to offering a safe and welcoming environment, ensuring that residents receive the necessary care and support to maintain their well-being and quality of life.

3.4.1 Description of the pilot site

The building is composed by 4 floors and one basement with technical facilities, storage rooms etc. There are 58 single rooms and 4 double rooms, for a total of 66 beds. Each room has a private bathroom with wheelchair-accessible shower, direct-dial telephone, a balcony and basic furniture. On the ground floor there are the entrance, the living room-bar with reception and administrative offices. Also, there is the kitchen with direct access to the large multi-purpose room, which has movable walls to create a dining room when needed, the leisure entertainment room and the chapel.



Figure 15. Casa Massagno building

Casa Girasole is part of the energy community “Motta District” developed by AEM. The urban district of Via Motta in Massagno consists of approx 20 residential flats and single houses. The buildings are two multi-family 5 floors buildings and three typical two-store family houses. The area covers an area of approx. 8000 m² and there are around 105 residents. In the district there is also a large office building with engineering and legal offices. Nearby there is a 60kWp PV plant installed on the roof of the local shelter for elderly people. Other buildings in the area are different restaurants and bars, a cinema and a church.

The main users of the facility are the elderly people with reduced autonomy. Other users are the healthcare and administrative employees of the facility. The parking area in front of the house is public and is mainly used by employees and external visitors. The parking area is free to access but it has limitation on the duration of the stop, with some exceptions specific for the facility. Moreover, there is an area dedicated to accessible parking. There is already an EV charging station installed in the pilot area, while unidirectional charging capabilities and forecasts on user profile data, as the infrastructure is public, will be investigated.



Figure 16. Examples of sensors installed or planned in the building

From a technical perspective, in selected areas of the building, battery-powered Shelly Plus H&T sensors could be installed to monitor humidity and temperature and visualize the values on a display. In selected areas, there are cabled Netatmo Home Coach installed to measure indoor temperature, relative humidity, sound levels and CO₂ concentration. Other systems as Shelly Blu Door Windows

(battery-powered) could be installed in some rooms to detect the opening and to measure the inclination angle of doors and windows. Moreover, 2D and 3D drawings of the building and the parking area will be made available to develop BIM models and proceed with the work in the project.

3.4.2 Analysis of needs and requirements

The main users of the building are elderly people who are unable to live independently at home and require professional medical care and assistance from qualified staff. The needs and requirements in terms of energy comfort of these types of users is different from the average usage patterns and values, and will have to be taken into consideration when demonstrating the Access Suite tools. Also, specific engagement strategies shall be planned and applied to ensure privacy and active participation in an accessible way for elderly people. Moreover, the pilot is interested in improving the parking area in the front of the building with accessible infrastructure that includes EV charging points, for workers or visitors with reduced mobility.

3.5 Palazzo di Città, Bari, Italy

Bari is the capital city of the Apulia region, in the southern Italy on the Adriatic Sea. It has a total population of 315284 inhabitants with an area of more than 116 km². It is the capital as well of the Metropolitan Area of Bari, with a total population of 1.3 million people.

Since 2022 Bari has adopted actions to respect the Plans of eliminations of Architectural Barriers (Piani di Eliminazione delle Barriere Architettoniche – PEBA) on its territory to implement a series of interventions to improve accessibility to public spaces for physical or sensory disabled citizens, allocating 300.000 € for the purpose. The municipality implemented 40 actions such as parking spaces reserved for disabled people, sensory indicators and dedicated signage etc. Moreover, Bari has applied the “Bari Smart City” action plan that is included in the non-profit project called “City Plus” to include disabled citizens, local associations and entities, industries and stakeholders to improve accessibility at the urban level.

The Bari Living Lab implemented in the IN2CCAM project [21] aimed to enhance Connected, Cooperative, and Automated Mobility (CCAM) services through simulations and data assessments. This initiative aimed to develop innovative solutions for both passenger and freight transport within urban environments by creating a Route Planner to facilitate CCAM usage among diverse social groups, promoting inclusivity, and simulating new urban freight transport and last-mile logistics models to reduce vehicle circulation in urban areas. Through these efforts, the Bari Living Lab aimed to create a more inclusive, efficient, and sustainable urban mobility ecosystem, aligning with broader goals of enhancing traffic management and promoting the adoption of automated mobility solutions.

In recent years, Bari has aimed to improve the accessibility of its services to the citizens, creating listening and information points, rethinking tourism and improving the accessibility of places. Even in the design of public spaces there is greater attention to the choice of furnishings, games for the little ones, but also sports equipment so that recreational and recreational activities can be truly enjoyable.

Furthermore, the municipality has developed an E-gov portal which has improved citizen accessibility to the main services required [22].

3.5.1 Description of the pilot site

The Palazzo di Città is located in the city center of Bari and hosts the main municipal offices since 1860. The Palazzo hosts the wedding and public relations offices, and also the Mayor’s office, with a frescoed

ceiling by Nicola Colonna from the early 1900s. Adjacent to the Mayor's Office is the Sala Massari, named after Giuseppe Massari, Bari's first Deputy to the National Parliament post-Italian unification. The room features his marble bust by sculptor Emilio Tadolini, among other notable sculptures. Moreover, there are two main rooms, Sala Giunta and Sala del Consiglio, in which the main political activities of the Municipality take place, which house historical furniture and decorations as hand-carved mirrors, portraits of past mayors of Bari and a grand wooden carving of the city's coat of arms from the 19th century.



Figure 17 Frescoed ceiling in the Mayor's Office room

The Palazzo is formed by two communicating wings and also incorporated the Piccinni theatre, the city's first permanent theater, which is recognized as an architectural asset of cultural interest. The building footprint is around 4.800 m² and is composed by a basement and three floors on the west side, and a basement and four floors on the east side.



Figure 18. Palazzo di Città and Piccinni Theater

The Palazzo di Città faces Corso Vittorio Emanuele and the adjacent Piazza Libertà, a central hub of the city. The building's regular form is bordered by Via B. Cairoli, Via N. Piccinni, and Via R. da Bari.

Recognizing the building's significant social and cultural value, deeply rooted in the community's consciousness, a comprehensive energy efficiency project has been developed. The goal is to enhance one of the city's most iconic monuments, ensuring that occupants experience improved thermal comfort, especially during colder periods. This initiative addresses current thermal losses attributed to outdated fixtures that fail to meet modern thermal and acoustic standards.

The project emphasizes the preservation of the building's historical integrity. Existing fixtures, believed to date back to the original construction, are of clear historical value. Therefore, design choices have been meticulously evaluated in collaboration with the Superintendence to balance all requirements of Cultural Heritage. The plan includes restoring less deteriorated existing fixtures and installing new ones that replicate the original design, ensuring appropriate thermal and acoustic performance. Water-based paints will be used for finishing to enhance resistance to atmospheric agents and minimize environmental impact. In agreement with the Superintendence, floor-mounted fan coil units will be installed to minimize alterations to the building's historic vaults and walls. Additionally, some interior flooring will be replaced to accommodate the new conditioning system's conduits, using materials consistent with the original or adjacent spaces to maintain overall harmony. The total estimated cost for the intervention is €3.500.000. The Technical and Economic Feasibility Project (PFTE) and the definitive project have been approved, with the executive project forthcoming. The project involves interventions aimed at energetically redeveloping the building and improving the quality and thermal comfort of the work environments. In particular, to improve the energy performance of the fixtures, the distribution system of the summer and winter air conditioning systems and the MV/LV energy distribution system of the internal lighting.

Multiple inspections were necessary by the Superintendence which verified the compatibility of the interventions with the need to preserve the historical and cultural value of the building. The building currently has energy class D. In the technical report, emphasis was placed on energy analysis and an attempt was made to intervene to reduce energy waste.

Therefore, the first interventions planned are the replacement of the lighting fixtures with LED lamps and the replacement of the existing air conditioning system with a new system equipped with electric heat pumps that use aerothermal energy.

In front of the pilot building, in Corso Vittorio Emanuele II Street, there are two EV charging stations freely accessible all day. The first is a Type 2 charging station with a maximum power output of 22 kW, suitable for most modern EVs and offering fast charging capabilities. The second is a Type 3A charging station with a maximum power output of 4 kW, designed for smaller vehicles or lower power needs, such as scooters or older EV models.

3.5.2 Analysis of needs and requirements

Following the Plans of eliminations of Architectural Barriers, there are no obstacles and gradients to access the building and more than one elevator is present, but there are no routes for the blind people and accessibility is guaranteed by the absence of obstacles and gradients. The building is currently equipped with ramps and elevation devices to ensure accessibility for the physically disabled. On a wider perspective, the Municipality would need to increase the accessibility of the public website from a structural and digital point of view. Furthermore, it would be appropriate for the theater to also be accessible. The public relations office was recently set up on the ground floor to make it accessible and usable by all.

Also for Palazzo di Città, the same rules for the adoption and management of cloud infrastructure and public data access described for the Brancacci chapel in Florence apply. The AccesS project will take these regulations into consideration as well for the pilot in Bari throughout the project activities.

It could be interesting to install presence detectors for counting people, not just those who work inside the building who have to use the badge when entering and exiting. Furthermore, it could be useful to have detectors for thermo-hygrometric conditions.

The municipality also has a website [23] which is created with the aim of guaranteeing the best usability for both disabled and non-disabled visitors. The usability of a website, the usability of its contents, is very important in the design of a website because it influences the quantity and satisfaction of visitors who browse it. The website was created paying great attention to the regulations and the most effective strategies relating to the usability of the contents of a website. The technical office, having prepared the technical feasibility project for the energy efficiency of the building and for the restoration of the elevations, is able to provide the DWG documentation to develop a BIM model. The executive project has currently been commissioned.

3.6 Mercado de Veronicas, Murcia, Spain

Murcia is a city in the southern part of Spain, capital of the autonomous community of Murcia, with a total population of 460.349 as of 2021.

The city approved in 2015 the Murcia Smart City Strategic Plan (Smart Murcia). Since then, the city has been very active developing the project “MiMurcia: your Smart, Close, Open and Innovative City Hall”. Murcia city has focused on increasing universal accessibility in green spaces and public facilities, transportation systems and developing digital services for people with disabilities. One example is the launch of the “Murcia Accessible 010 App” in which the 010 Citizen Attention Service has been adapted for people with hearing impairment.

3.6.1 Description of the pilot site

The Mercado de Veronicas building is a municipal market of the Municipality of Murcia built between 1912 and 1916 by Pedro Cerdán Martínez. The building has been already renovated in 1975 introducing mezzanine floors, altering the original interior's open layout but preserving the facades. Mercado de Veronicas is a two-floor historic building with a surface of 3.000 m² to be renovated. The first floor at ground level will keep its commercial use as a public market, while the second floor will include restaurants and spaces for educational and cultural activities related to cooking and local food products. The renovation will adapt the building to the current regulation with focus on accessibility and inclusiveness and will improve energy efficiency, reducing energy consumption and CO₂ emission by over 50%.



Figure 19. Mercado de Veronicas, Murcia

Mercado de Veronicas is the subject of an extensive renovation plan funded under the NextGeneration EU program, which is composed by two main phases. Phase 1, with a public subsidy of 3.000.000 €, will start in January 2025 and will last until December 2025. Phase 1 includes envelope works (roof, façade) and upper floor (mezzanine), mainly affecting the external part of the market. Soon after the end of Phase 1, Phase 2 will start affecting the internal area, including re-organization of shops to optimize the internal space, upgrades of electrical, plumbing and ventilation systems, improving decorative elements to increase attractiveness and improve usability and accessibility of entrances and pathways for people with reduced mobility. In particular, Phase 1 includes the restoration of facades, replacement of exterior carpentry, waste management and underground electrical installations. Moreover, the thermal envelope will be improved to meet the current energy policy in EU, including roof replacement and humidity repairs. Prefabricated materials will be exploited for temporary facilities (i.e., storage, office spaces etc.), while measures for fire prevention and noise reduction are foreseen, and automatic doors are planned to be installed in four entrances for energy efficiency and accessibility. The renovation plan will also serve to meet compliancy with regulations on fire and structural safety, energy efficiency and accessibility while respecting its cultural importance. The roof replacement work will not interfere with the activity on the ground floor, while the positions on the upper floor will be moved downstairs or temporarily closed. This will not affect the pilot, as it will focus on the ground floor, which concentrates practically all of the activity and influx of people to the building.

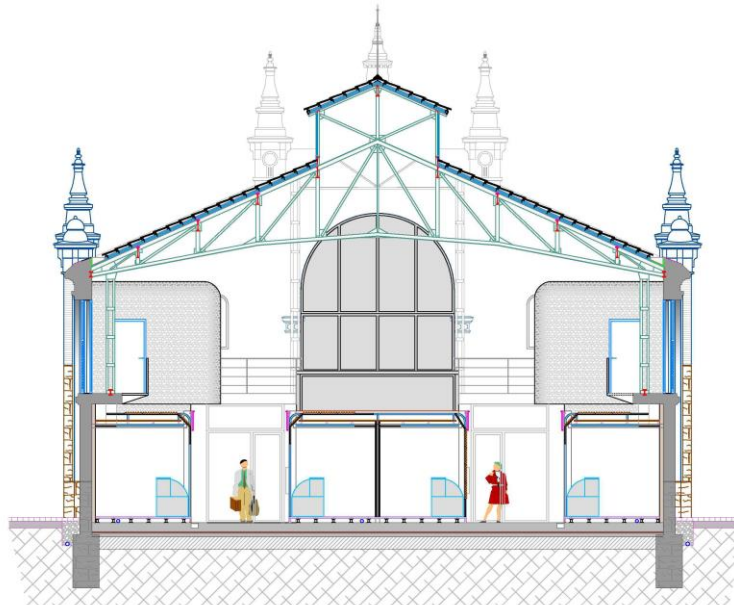


Figure 20. Details on renovation works of Phase 1

3.6.2 Analysis of needs and requirements

The renovation follows the concept of New Bauhaus as a result of Murcia participation on the Urban Agenda for the EU Partnership for Culture and Cultural Heritage. As part of the Murcia Smart City Strategic Plan (Smart Murcia) and “Mi Murcia” project, the city has performed co-creation activities with the citizens to engage them and gather feedback in order to plan specific actions within the smart city objectives of the city. This process will continue and proceed in synergy with the AccesS project. The objectives for the market would be to increase the digitalization of the building to attract young people, by providing them online details as information on products and delivery, while not penalizing the experience for elderly customers. Via real-time information, Murcia would like to flatten the presence curve to offer a more pleasant and stress-free shopping experience, enhanced via real-time accessible information on shops location, working hours and services as escalators, elevators, toilets etc. Additional useful information to be made available for the users are environmental conditions of the inner areas of the market as humidity, temperature, air quality and lighting, to enhance accessibility and ensure user comfort. Moreover, the renovation works will not have a significant impact on shop owners during Phase 1. The only shops that will be affected would be those in the upper floor (mezzanine), that will close or be moved to the lower floor. These shops are approximately less than 25% of global market activity.

In addition, plans for responsible disposal and recycling of construction materials have been done in the view of improving the market’s energy efficiency and reducing its environmental footprint. Lastly, the historical value of the building and its cultural relevance have to be taken into consideration and preserved in the renovation works.

Phase 2 of renovation will include the deep and complete renovation of building’s interior (pavement, shops, active systems, facilities, etc). There is no scheduled date for this work, which is expected to begin after the development of the AccesS project.

4 Business Scenarios & Use Cases Definition

A business case or scenario (BS) reflects the need or problem that allows grasping the business value. It may also reflect the reasoning that enables a decision to start a project. A common practise usually followed for properly identifying and defining business scenarios, is that it must be “SMART”:

- **Specific**, by defining what needs to be done in the business
- **Measurable**, through clear metrics for success
- **Actionable**, by clearly segmenting the problem, and providing the basis for determining elements and plans for the solution
- **Realistic**, in that the problem can be solved within the bounds of physical reality, time and cost constraints,
- **Time-bound**, in that there is a clear statement of when the solution opportunity expires

In order to facilitate understanding the business value offered by AccesS, three Business Groups have been introduced aligned with the three pillars of project development as described in the Grant Agreement and Section 4 of this report, as well as following the market analysis and technology watch performed within T1.1 for accessibility, inclusivity and comfort, sustainable mobility and reduction of energy consumption and GHG emission. Those Business Groups reflect the needs and market demands of key target groups as identified in the Grant Agreement. The methodology adopted for the recognition of relevant stakeholders is specified by the Project Management Institute (PMI). This method applies a category approach to identify the important stakeholders based on three categories. According to this definition, a project stakeholder is, "an individual, group, or organization, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project." AccesS Key Target Groups are analysed in the following table.

Table 4. Description of AccesS Key Target Groups

Key Target Groups	Description	Types of individuals/ groups
Those who affect the creation of an accessible and inclusive built environment	This category includes the stakeholders participating in the delivery of accessible and inclusive buildings and cities and those who determine the context for that. This category mainly includes organizations/companies designing and constructing the built environment and developing relevant software as well as the entities who set the legal framework and specific rules for accessibility. National policies and legal framework set the scope (tasks) for regulation and for the promotion of accessibility, comfort and inclusiveness within communities, standardization organizations develop standards with experts in Technical Committees developing the methodology for assessment.	Building Industry, Professional consultants (e.g., architectural, engineering and financial), Tool developers Energy service companies (ESCOs), Building Material and Product Industries, State/Governmental Departments – Public Bodies EU legislative instruments Standardization organizations

Those who are affected by the creation of an accessible and inclusive built environment	This category includes the stakeholders who are directly or indirectly affected by the creation of accessible and inclusive buildings and cities. Inclusive smart buildings should incorporate universal design principles, ensuring that the physical environment, infrastructure, and technologies are usable by all individuals, regardless of their abilities. The property value for rental or sale can also be affected by the accessibility in a building.	Users of the buildings, Owners/Users, Facility managers, General Public, Local community groups such as resident associations, social cooperatives or other community-based groups
Those who are interested in the creation of an accessible and inclusive built environment	The stakeholders under this category may be interested on the outcomes and methodology for creating environments that are accessible and supportive for all individuals for different applications according to the context.	Researchers/ Academia, Environmental/ social campaigning organisations, organisations representing people with disabilities, Potential users/clients for future projects

In order to deliver the main business scenarios, it is necessary to further break them down to smaller, more technical-oriented steps, depending on the different digital tools accessed through the integrated Access Suite. These are the **technical Use Cases**. A Use Case is a list of event steps typically defining the interactions between a system and an actor to accomplish a specific goal (i.e., business scenario).

Access Business Scenarios and Use Cases are described in the following sections.

4.1 Business Group A: Common evaluation and certification of Accessibility

This group reflects the pressing need to establish a comprehensive and harmonized certification framework specifically focused on accessibility and inclusiveness in the built environment. The development of such a framework would aim to provide a standardized and integrated approach for evaluating and promoting accessibility in buildings.

4.1.1 BS1: Assessment of accessibility for the built environment

This business scenario aims to deliver the core functionalities of the AccessS Accessibility Assessment tool aiming to assess the design and operation of building and infrastructure according to the developed Accessibility Assessment Scheme. This will encompass not only physical accessibility but also usability, safety, comfort, and the crucial aspect of social inclusion. By addressing these facets, the scheme aims to guarantee that the built environment is not only physically accessible but also inviting, user-friendly, and supportive of diverse needs.

This business scenario consists of the following technical use cases:

- UC1.1- Assessment of physical accessibility
- UC1.2- Assessment of usability, safety and comfort

- UC1.3- Assessment of social inclusion
- UC1.4- Issue an assessment report according to AccesS Accessibility Assessment Scheme

4.2 Business Group B: Design of accessible and inclusive built environment

This business group reflects the main business scenarios delivered by AccesS digital innovations for the design of an accessible and inclusive built environment. Focusing on aspects such as energy efficiency, user comfort and ergonomics of products, these scenarios will facilitate the digitalisation and sustainable design of building and building products while meeting the needs of people with disabilities and older adults, including their virtual representation in the form of virtual user models and virtual humans to support the demonstration of design issues that should be considered to improve the capacity of delivering solutions designed for all.

4.2.1 BS2: Optimization of energy efficiency and user comfort

This scenario is focused on optimizing energy efficiency and user comfort by delivering specific KPIs for the building's performance in its current state and providing recommendations for renovation scenarios to support decision making. Additionally, this scenario delivers practical information on the user's comfort in relevance to energy efficiency and monitors their impact to optimise building design.

To fully cover this scenario the following technical use cases have been identified:

- UC2.1- Assessment of baseline building energy performance
- UC2.2- Generation and evaluation of BIM-based renovation scenarios
- UC2.3- Visualization of baseline and renovation scenarios KPIs to support decision making
- UC2.4- Simulate occupant comfort levels and its impact on the building's energy consumption
- UC2.5- Monitor occupant comfort levels and its impact on the building's energy consumption

4.2.2 BS3: Design of ergonomically adapted products

This scenario is focused on delivering 3D designs of ergonomically compliant products. Its business value is connected in particular with designers and manufacturers for supporting them in creating products that prioritize comfort and accessibility. To fully cover this scenario the following technical use cases have been identified:

- UC3.1- Evaluate the ergonomics of 3D models of furniture items
- UC3.2- Visualisation of ergonomics results of products

4.2.3 BS4 Realistic human representation and simulation of user experience

This scenario will allow simulating user experience under different use cases and facilitate understanding of user needs under specific contexts. It will properly represent human features and their interaction under different scenarios to promote accessibility and inclusion while supporting the demonstration of design issues that should be considered to improve the capacity of delivering solutions designed for all.

To fully cover this scenario the following technical use cases have been identified:

- UC4.1- Digital authoring of Virtual User Models (VUMs)
- UC4.2- VUM-based Virtual Human authoring
- UC4.3- 3D Simulation for Wheelchair building accessibility
- UC4.4- 3D Simulation for building accessibility for the elderly
- UC4.5- 3D Simulation for building accessibility for visually impaired people
- UC4.6- 3D Simulation for building accessibility for auditory impaired people

4.3 Business Group C: Intelligent, adaptive and sustainable operation of the built environment

This business group reflects the main business scenarios delivered by AccessS digital innovations for the operation of an intelligent, adaptive and inclusive built environment. Focusing on aspects such as energy efficiency, user comfort and grid flexibility, these scenarios will support adaptive building operations, improving comfort, efficiency, and sustainability with real-time data. Additionally, it integrates aspects of electromobility as active building element, optimizing EV charging infrastructure and grid balance.

4.3.1 BS5: Monitor and Optimize building operation

As stated above, this scenario aims to provide real-time information on building operation to the end-users. Starting from simple monitoring of raw data or performance metrics, to more thorough visual analytics and recommendation for improving operational conditions in parallel with user comfort and energy forecasts. Through this business scenario, it is also possible to monitor accessibility features in GIS environment

- UC5.1- Provide real-time/historical information on building's energy performance
- UC5.2- Provide real-time/historical information on building's indoor conditions
- UC5.3- Provide recommendation for improving operational energy performance & conditions in terms of health and comfort
- UC5.4- GIS visualisation of accessibility features

4.3.2 BS6: Integrate Electric Vehicles as Active Building Element

This business scenario aims to allow the integration of electric vehicles as active building elements by optimising EV charging by considering energy conservation while catering to user-specific needs. Aiming also to secure grid stability, this scenario will utilise EVs as storage units that can supply energy back into the building grid. To fully cover this scenario the following technical use cases have been identified:

- UC6.1- Optimise EV Charging in Building Infrastructure
- UC6.2- Enable EVs to Act as Distributed Energy Resources (DERs)

5 AccesS Conceptual Architecture

5.1 The Three Pillars of Development

The AccesS project is structured around three key pillars, as showed in Figure 21, each aimed at transforming the built environment to be more accessible, inclusive, and sustainable. Each pillar supports innovative tools that enhance adaptability to diverse user needs while improving energy efficiency and comfort. Below is a brief elaboration on the three pillars:

Pillar #1: Methodological framework for user-centered design and accessibility assessment scheme

This pillar focuses on developing a standardized approach for designing accessible environments that prioritize user needs. By involving diverse stakeholders such as disability advocates, architects, and policymakers, the AccesS framework provides guidelines for inclusive, accessible spaces. It ensures buildings meet accessibility standards through an assessment scheme that identifies barriers and proposes improvements, ensuring environments are adaptable to all users, including those with disabilities and older adults.

Core Components:

- Universal Accessibility Assessment Tool (T7.1)

Pillar #2: Accessible and inclusive design of the built environment through software-driven innovations

This pillar enhances the design process by utilizing advanced modelling and simulation tools to create energy-efficient and sustainable buildings. The Energy Efficient and Sustainable Design Tool employs BIM technology, allowing for integration with various software services to simulate different usage scenarios and optimize performance. Additionally, the Energy Comfortness Tool focuses on the relationship between energy efficiency and user comfort, encouraging sustainable practices. An Ergonomic and Comfort Design tool provides expert recommendations to optimize ergonomics and improve comfort for products tailored to individuals with disabilities and older adults, ensuring that the built environment is both functional and user-friendly. To accurately represent users and context, Virtual User Models (VUMs) and VUM-based Virtual Humans will be created by extending the state-of-the-art in the area of modelling of users with disabilities, and will be assessed in 3D simulation environments to improve design issues and deliver spaces designed for all.

Core Components:

- Energy Efficient and Sustainable Design Tool (T4.1)
- Energy Comfortness Tool (T4.2)
- ErgoFlow (T4.3)
- Virtual User Models and VUM-based Virtual Humans (T5.1)
- 3D Simulation Environments (T5.3)

Pillar #3: Intelligent, adaptive and sustainable operation of the built environment, including e-mobility and micromobility

This pillar focuses on smart management of buildings through an adaptive Building Operation and Management System (BOMS). It connects with existing systems and collects real-time data to monitor energy use and performance. Using big data and AI tools, BOMS optimizes building efficiency and user

comfort. It also integrates electric vehicle (EV) charging, allowing EVs to become active parts of the building's infrastructure, supporting sustainable operations and enhancing user experience.

Core Components:

- Adaptive Building Operation and Management System (BOMS) (T6.1)
- EV Charging Optimizer (T6.3)

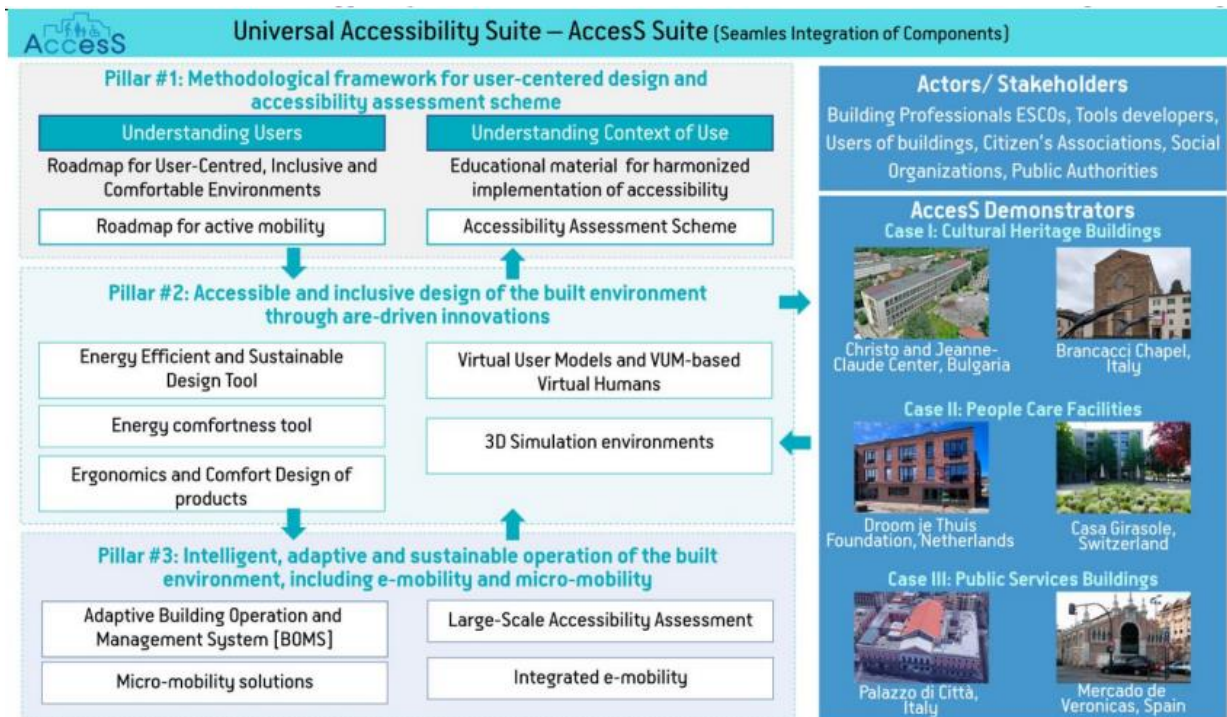


Figure 21. The Three Pillars of Development

5.2 Layered Conceptual Architecture Perspective

The Layered Conceptual Architecture Perspective provides an organized view of how different tools and systems work together within the AccesS Suite. It shows how user interfaces, data processing, and technology integration come together to improve accessibility, energy efficiency, and comfort in smart environments. This structure supports the development of simulations and AI-driven tools for better building management and sustainable design of the built environment.

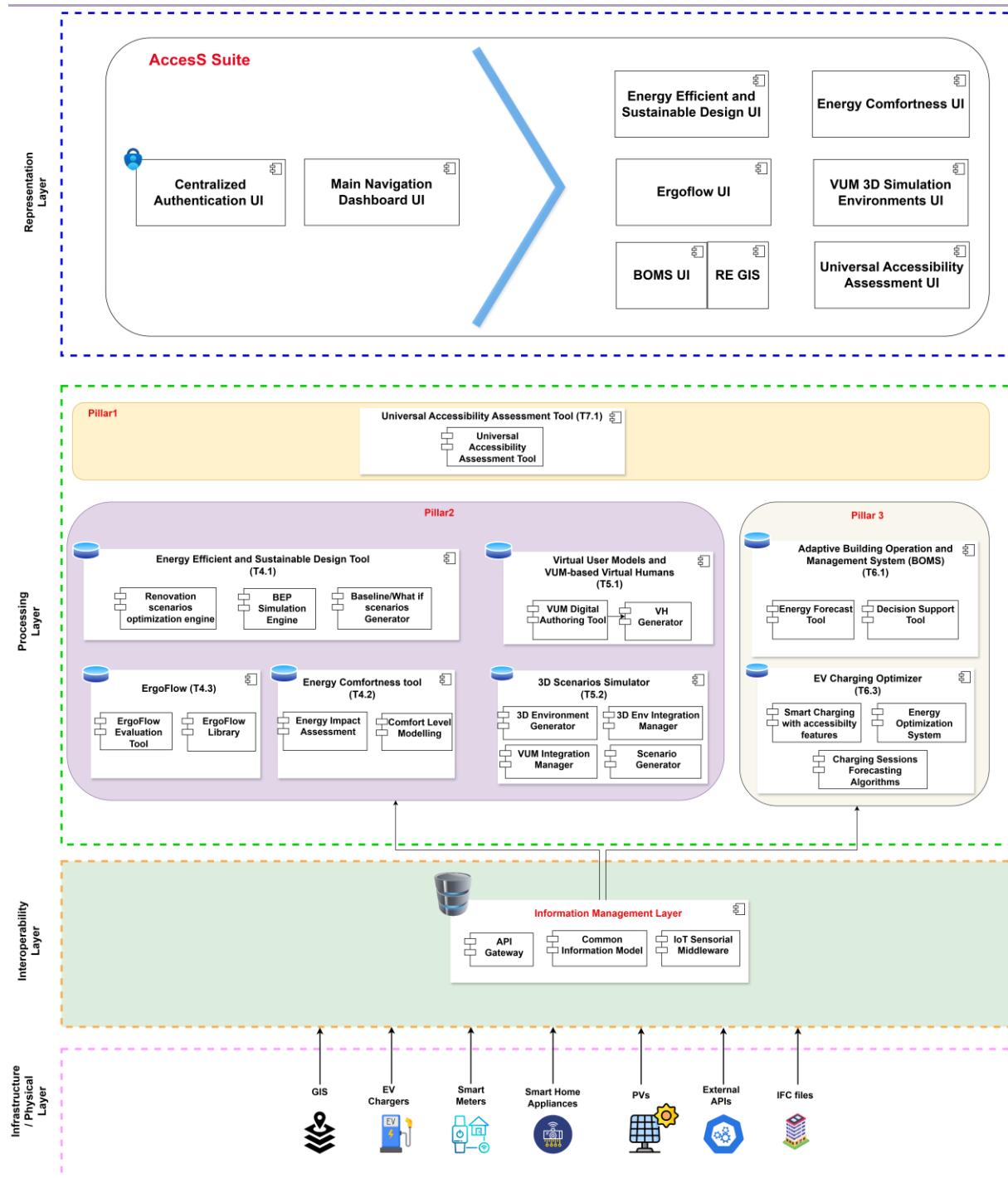


Figure 22. AccesS layered conceptual architecture

The layers of AccesS conceptual architecture shown in Figure 22 are described below in a brief manner:

Infrastructure/ Physical Layer: This layer is responsible for data collection, where devices, sensors, and various systems gather essential building information for use by the upper layers. BIM models in IFC formats, along with dynamic data from sensors and APIs are utilized to optimize energy efficiency and comfort at the building level and facilitate simulation design.

Interoperability layer: This layer retrieves, stores the data and handles its conversion into a standardized format before passing it to the upper layers. It also includes API services that enable efficient transmission of the data to other systems.

Processing layer: This layer consists of the core Access components and subcomponents for delivering all the main functionalities envisioned. It integrates and analyses data from various sources, such as BIM models and sensor inputs, to optimize building performance. This layer runs algorithms and simulations to assess energy efficiency, accessibility, and comfort, providing actionable insights and recommendations. It effectively transforms raw data into valuable information for decision-making and system improvements.

Representation layer: This layer ensures that users (e.g., building professionals, facility managers, and designers, residents etc.) can interact with the system, monitor performance, and make data-driven decisions about the building's energy use, accessibility, and comfort. It includes a centralized interface that provides access to all the core tools and features. This includes dashboards for visualizing BIM data, energy simulations, and accessibility features, among others.

6 System Requirements

In line with the design methodology and in parallel with other WP1 activities, the technical and user requirements have been identified to more clearly define the functionalities of the AccesS architecture. This process is aimed at ensuring the successful delivery of the Business Scenarios outlined in Section 4. To enhance the clarity and organization of the gathered requirements, they have been grouped based on common functionalities shared by the various tools that the AccesS Suite will need to support. This structured approach facilitates a better understanding of the system's capabilities and its ability to meet user needs. In the following subsections, both the functional and non-functional requirements are provided to offer a comprehensive view of the system's expected behavior and performance criteria.

6.1 Functional Requirements

Functional requirements describe the behaviors, features, and operations of the system that are necessary to accomplish a given goal. Furthermore, these requirements describe the functionality of the system, and what is the expected outcome. Within this system, functional requirements fall into two categories: authentication requirements and tools requirements. Authentication requirements outline the precise technical actions and procedures of user verification, session management, and access control to complete the user authentication. This ensures that only authenticated users can use the system's resources without compromising the security of the system. Tools' requirements outline the precise technical description of each individual component and their functionalities. These requirements ensure that users access the system's features in the expected ways and that the desired results are achieved.

6.1.1 Authentication Requirements

The requirements outlined and described in Table 5 are defined to ensure a secure, user-friendly authentication and registration system for the platform. These requirements cover critical functions such as user login, password management, account registration, and security mechanisms. All these functionalities form the foundation of a secure and efficient access control system that protects user data, supports user convenience, and aligns with best practices in security and usability.

Table 5: Authentication Functional Requirements

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
Auth-01	The platform should allow users to log in with a valid username and password.	CERTH	Enable secure access to the platform for authorized users.	T7.2	Users can log in with a valid username and password, receiving access to authorized resources.	High
Auth-02	The platform should provide an option for users to reset their password through a "Forgot Password" feature.	CERTH	To ensure users can regain access if they forget their password.	T7.2	Users receive a password reset link via email upon request and successfully reset their password.	High
Auth-03	The platform should verify users' identities through email for the "Forgot Password" feature.	CERTH	Prevent unauthorized access by confirming users' identities.	T7.2	Password reset link is sent only to registered email addresses, and identity is confirmed.	High
Auth-04	The platform should allow users to change their password after logging in.	CERTH	Enable users to maintain secure accounts by updating their password regularly.	T7.2	Logged-in users successfully change their password and can log in again with the new password.	Medium
Auth-05	The platform should provide a registration form for new users to create an account.	CERTH	Enable new users to register and access the platform's services.	T7.2	Users complete the registration form, submit it, and receive a success confirmation.	High
Auth-06	The platform should send a confirmation email upon successful registration.	CERTH	Verify the user's email address and confirm successful account creation.	T7.2	Users receive a confirmation email with a link to activate their account.	High
Auth-07	The platform should restrict duplicate registrations with the same email address.	CERTH	Prevent duplicate accounts and ensure each email is unique to a single account.	T7.2	Users attempting to register with an existing email address receive an error message.	High

ID	Description	Partner	Rationale	Origin/Source	Fit Criterion	Priority
Auth-08	The platform should encrypt passwords using strong cryptographic algorithms before storage.	CERTH	Protect stored passwords from unauthorized access through secure cryptography.	T7.2	Passwords are encrypted, stored securely, and never accessible in plain text.	High

6.1.2 Tools Requirements

Table 6 describes the functional requirements for the digital tools developed and implemented within Access Suite. It specifies the capabilities and features each tool must have to ensure proper data handling, compatibility, and overall system functionality.

Table 6. System Functional Requirements

ID	Description	Partner	Rationale	Origin/Source	Fit Criterion	Priority
Tools-01	The platform should be able to read building geometry, orientation, materials, and systems from IFC-based BIM files.	QUE, UNIS	Need to develop an interface for reading and parsing data from BIM documents.	T4.1	The platform successfully reads and parses IFC data.	High
Tools -02	The platform must read near real-time energy monitoring data from smart sensors on a scheduled basis or upon request.	QUE, UNIS	Enable continuous energy efficiency monitoring through sensor data integration.	T4.1, T4.3	System reads and processes within defined intervals.	High
Tools -03	The platform must allow user input to modify the initial IFC files.	QUE	Need to run different renovation scenarios based on provided IFC files.	T4.1	Users can choose different appliances and smartification products for various scenarios.	High

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
Tools -04	The platform must represent the actual energy performance of buildings within a BIM environment.	QUE, UNIS?	Need to visualize the building in a 3D environment.	T4.1	Users can see the building's energy performance in 3D.	High
Tools -05	The platform must provide an interface for users to view current energy efficiency data and related KPIs, access baseline performance, explore renovation scenarios, and visualize potential savings.	QUE	To facilitate the informed decision-making on renovations through a comprehensive front-end solution.	T4.1	Users can navigate scenarios and view visualization and KPIs for energy savings.	High
Tools -06	The platform must incorporate deep neural algorithms for forecasting energy consumption and RES production.	CERTH	To support the decision-making on building operations.	T6.1	Forecasts are generated based on historical and real-time data inputs.	High
Tools -07	The platform must integrate adaptive control strategies based on inputs and user's preferences.	CERTH	To optimize building operations and ensure energy efficiency while maintaining user's comfort.	T6.1	Adaptive strategies are implemented and can be modified in real-time.	High
Tools -08	The platform should provide real-time optimization suggestions for building operations to balance comfort and energy use.	CERTH	To offer optimal operational solutions and reduce energy costs while maintaining user comfort.	T6.1	Optimization algorithms run continuously and generate actionable suggestions.	High
Tools -09	The platform must provide a user-friendly interface for users to view real-time data, forecasts, and optimization suggestions. And location specific accessibility features	CERTH	To ensure users can easily interact with the platform and make informed decisions on building operations.	T6.1	Users can view and interact with data and forecasts via GIS supported interface.	Medium

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
Tools -10	Identification of constraints for EV charging infrastructure including optimal charging point distribution and grid capacity.	HIVE	To establish a foundation for effective EV integration within building infrastructure.	T6.3	Constraints are accurately identified and documented.	High
Tools -11	The platform must develop predictive algorithms to personalize EV charging behaviour, taking into account user accessibility needs.	HIVE	To create a smart charging system that accommodates the needs of users with disabilities and elderly individuals.	T6.3	Predictive algorithms provide personalized charging schedulers based on user behaviour.	High
Tools -12	Allow users to modify parameters related to charging preferences and accessibility features in real-time.	HIVE, CERTH	To enhance user experience and optimize charging behaviour based on individual preferences.	T6.3	Users can adjust charging preferences and see immediate updates.	High
Tools -13	The platform must provide a dashboard that displays real-time data on EV charging status, energy consumption, and grid load.	HIVE, CERTH	To facilitate user interaction and enable informed decision-making regarding EV charging.	T6.3	Dashboard displays real-time data and updates dynamically.	Medium
Tools -14	The platform must evaluate various algorithmic alternatives for forecasting energy consumption and EV production.	HIVE	To improve the accuracy of energy management for EV charging and building operations.	T6.3	Forecasting models demonstrate increased accuracy over existing models.	High
Tools -15	The platform must be able to detect inconsistencies and gaps in the input data to ensure data quality.	CERTH	Need to implement pre-process modules to detect possible missing or incorrect values in the input data.	T6.1	Prevent inconsistent and missing data that lead false results, calculation errors and in a low forecast accuracy.	High

ID	Description	Partner	Rationale	Origin/Source	Fit Criterion	Priority
Tools -16	The platform should simulate building's comfort levels using machine learning and physics-based models	UNIS	To accurately assess different comfort levels and their relationship to energy efficiency.	T4.2	Comfort simulations are completed within a specified time.	High
Tools -17	The platform should be able to visualize comfort levels results and energy efficiency KPIs.	UNIS, CERTH	To ensure that users can interpret the results and make informed decisions on design optimization.	T4.2, T6.1	Visualize Comfort Levels and KPIs	High
Tools -18	The platform should be able to read information on building geometry, orientation, building materials and building systems from a BIM document in IFC format	QUE	Need to develop an interface for reading and parsing data	T4.1	The platform should be able to read information on building geometry, orientation, building materials and building systems from a BIM document in IFC format	High
Tools -19	The platform should be able to read (near) real time data from smart sensors for the extraction of the operational rating of buildings on a regular timeframe or upon request.	QUE	Need to integrate with the CIM in order to retrieve the data.	T4.2, T6.1	The platform should be able to read (near) real time data from smart sensors for the extraction of the operational rating of buildings on a regular timeframe or upon request.	High
Tools -20	The system should prompt users with a questionnaire tailored to ergonomic analysis after model upload.	CETEM	Gather essential information to customize ergonomic analysis based on target group and environment.	T4.3	Questionnaire displays.	High
Tools -21	The system should generate a report detailing ergonomics, accessibility, comfort, and compliance with EU standards.	CETEM	Provide a comprehensive overview of the furniture's ergonomics for improvement and compliance.	T4.3	System produces a report with ergonomic, accessibility, and EU compliance data.	High

ID	Description	Partner	Rationale	Origin/Source	Fit Criterion	Priority
Tools -22	The system should permit the user to export the report in a PDF format	CETEM	Ensure report formats are universally accessible and easily shareable.	T4.3	Reports are generated in PDF formats without errors.	Medium
Tools -23	The editor should provide intuitive interfaces for configuring VUM parameters, such as demographics and disability types.	FORTH	Ensure that the user interface is accessible and straightforward for creating realistic VUMs.	T5.1	Users can interact with configuration parameters, including age, demographics, and disability options.	High
Tools -24	The editor must allow users to save and retrieve Virtual User Models for future use.	FORTH	Ensure that VUMs are reusable and accessible, enhancing flexibility in long-term projects.	T5.1	Users can save configured VUMs and retrieve them later for modification or reuse.	Medium
Tools -25	The editor should transform the VUM into VH.	FORTH	Enable the generation of VH based on the defined VUM.	T5.1	Editor can convert VUM into fully configured VH for use.	High
Tools -26	The editor should allow the integration of the VH to a 3D simulation environment.	FORTH	Ensure compatibility with 3D simulation platforms to enable integration of Virtual Humans.	T5.1	Virtual Humans can be integrated directly into 3D simulation environments for testing and interaction.	High
Tools -27	The system should be able to create 3D simulation environments for the assessment of VUM-based VHs.	CERTH	Enable the generation of synthetic or realistic 3d environments aligned with pilot case specifications using IFC files.	T5.2	3D Environments are configured based on the project's scenarios for evaluating VHs, with specifications defined through the IFC format.	High
Tools -28	The simulation environments must facilitate predefined scenario	CERTH	This requirement ensures that the VH applications are tested for accessibility in realistic, varied environments, addressing	T5.2	The simulation environments should run predefined scenarios, identifying accessibility challenges.	High

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
	evaluations for testing accessibility in diverse settings.		potential barriers to usability for diverse user groups.			
Tools -29	The system should export a report detailing whether the VH successfully passes the predefined accessibility scenarios.	CERTH	Evaluate the VH's performance in predefined accessibility scenarios and provide a report for further improvements.	T5.2	A report on whether the VH successfully completes the accessibility scenarios.	High
Tools -30	The system should evaluate the accessibility of selected environments using the AccesS assessment framework and the relevant accessibility scheme.	FORTH	Ensure that selected environments are assessed for accessibility according to the AccesS framework and established guidelines.	T7.1	The system performs a comprehensive accessibility evaluation of the selected environment, highlighting any compliance issues.	High
Tools -31	The system should export a report detailing the results of the accessibility evaluation, including areas of non-compliance.	FORTH	Provide a clear report based on the accessibility evaluation results.		A report is generated and exported, summarizing the accessibility assessment findings.	High
Tools-32	The platform must provide a selection of spaces for energy comfortness evaluation.	UNIS, Pilots	Offer a selection of spaces that related to available BIMs. The space selection will required validation by the pilots.	T4.2	End-users will be able to select a space to build their scenario.	High
Tools-33	The platform must provide a selection of occupant profiles to the end-user.	UNIS, Pilots	Offer occupant profiles which are described by occupant-centric variables (e.g. age, metabolic rate, clothing) used in the valuation of comfort levels. The profiles will require validation by the pilots.	T4.2	End-users will be able to select an occupant profile to build their scenario.	High

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
Tools -34	The system should export a report detailing the results of the accessibility evaluation, including areas of non-compliance.	FORTH	Provide a clear report based on the accessibility evaluation results.		A report is generated and exported, summarizing the accessibility assessment findings.	High

6.2 Non-functional Requirements

Non-functional requirements are those that specify the quality attributes. Specifically, they describe how the system performs rather than how the system operates. Examples include performance, scalability, security, usability, reliability and maintainability. Non-functional requirements ensure that the system meets the necessary regulation and standards of efficiency and user experience under varied conditions. Thus, non-functional requirements are crucial for defining the overall behaviour of the system, ensuring its success and continuous improvement. The table below outlines each requirement in detail:

Table 7 Non Functional Requirements Table

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
AccesS-01	The platform should ensure high availability and minimal downtime for all services, particularly for real-time energy monitoring, building performance analysis, and user interaction.	-	To maintain continuous and uninterrupted service for users.	-	Platform availability of 99.9% or higher.	High
AccesS-02	The platform must be scalable to handle increasing amounts of data from sensors, BIM files, and user inputs without degrading performance.	-	Ensure that the system can grow and accommodate a larger number of buildings, sensors, users, and renovation scenarios.	-	The platform should be able to scale horizontally or vertically as needed to handle 1,000+ buildings and sensors.	High

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
Access-03	The platform must support multi-tenancy to handle different organizations (e.g., different businesses or users) without cross-contamination of data.	-	Support for multiple clients with data isolation ensures the platform can serve various organizations or user groups simultaneously.	-	Each user or organization should have isolated data with no overlap between different users' data.	High
Access-04	The platform must meet performance criteria for real-time data processing.	-	To ensure fast, actionable insights for users making decisions on energy efficiency, comfort, or other related factors.	-	Data should be processed in near real-time with a latency of no more than 5 seconds for sensor data and 30 seconds for forecast generation.	High
Access-05	The platform should support high security and data protection standards.	-	Protect user privacy and sensitive building performance data.	-	Adherence to GDPR for user data, use of encryption protocols for data in transit and at rest, and regular security audits.	High
Access-06	The platform should be accessible, supporting diverse user needs, including for those with disabilities.	-	To ensure that the platform is usable by all users, including those with accessibility needs.	-	Compliance with WCAG 2.1 AA standards, providing support for screen readers, high contrast mode, and keyboard navigation.	Medium
Access-07	The platform should have low energy consumption, especially for cloud-based services that run continuously.	-	Ensure sustainability and reduce the carbon footprint of the platform.	-	The platform should achieve a PUE (Power Usage Effectiveness) of less than 1.5 in the cloud hosting infrastructure.	Medium

ID	Description	Partner	Rationale	Origin/ Source	Fit Criterion	Priority
AccesS-08	The platform should provide a highly responsive and intuitive user interface (UI).	-	A user-friendly interface will improve user adoption and facilitate decision-making.	-	UI response time should be less than 2 seconds for most interactions, and user interface should be rated 4+ on usability surveys.	High
AccesS-09	The platform should support multi-language interfaces to serve a global user base.	-	Allow users from different regions to interact with the platform in their preferred language.	-	The platform must support at least English, Spanish, French, and German.	Medium
AccesS-10	The platform must allow users to retrieve historical performance data quickly, even for long periods of time.	-	Users need to access long-term performance metrics and analyses for decision-making and compliance.	-	Query times for historical data should be less than 10 seconds for datasets older than 1 year.	High

7 Functional View

The Functional View of the system outlines the components responsible for delivering system functionality. These components are depicted as functional elements based on their roles and interactions with other elements. This view does not account for runtime operations but focuses on time-free and sequential execution semantics. It is a crucial perspective, as it reflects the system's quality attributes and impacts its performance, maintainability, and extensibility. To comprehensively address the Functional View, the following three specific sub-sections are included:

- **High-Level Description:** This section provides a general description of each component.
- **Subcomponents:** This section details the sub-components necessary for delivering the expected functionality.
- **Component Diagram:** This diagram illustrates the component, its sub-components, and their interactions with other components, including communication and data exchange. A table follows the diagram, listing all the interfaces that facilitate communication between components and/or with external services. Typically, a component diagram describes an individual component and its integrated sub-components while also indicating dependencies between components.

7.1 Information Management Layer

7.1.1 High-level description

The Information Management Layer is a core component in the AccessS architecture responsible for collecting, storing, integrating, and processing data from IoT devices, external APIs, and building information models (BIM). This layer facilitates data integration and transformation, ensuring interoperability by standardizing measurements for consistent use across all components in the processing layer.

7.1.2 Subcomponents

7.1.2.1 Database

The Database is the central repository for storing all incoming and processed data. It ensures data persistence, allowing for long-term storage and easy retrieval. Direct access to the database is restricted to maintain data integrity, with only authorized components able to interact through managed interfaces. Specifically, the database stores raw data from sensors installed in the pilot environments, including power, environmental, and other sensor readings or data provided by APIs implemented by partner collection platforms. It also houses BIM data in IFC format, which contains detailed information about the building's structure and components. Additionally, the database stores encrypted authentication credentials to ensure secure access and user verifications.

7.1.2.2 API Gateway

The API Gateway acts as the central communication hub, routing data requests to the appropriate system components. It provides a secure interface for accessing data, ensuring that only authenticated and authorized interactions occur. This gateway prevents unauthorized direct access to the database, requiring all data exchanges to go through its controlled environment. All exchanges will be carried out through REST protocols, ensuring efficient and standardized communication between system components. The API Gateway also defines specific endpoints for each system, allowing for clear and

organized data access while maintaining strict control over the types of requests and interactions that can be made.

7.1.2.3 Common Information Model

This subcomponent standardizes incoming data by converting it into a unified format. Through the creation of a consistent schema, it addresses the challenges posed by varying data formats, ensuring integration and operation across all system components. This standardized approach simplifies data handling, reduces integration complexities, and guarantees that all parts of the system utilize harmonized data structures. As a result, efficiency is enhanced, and interoperability is ensured across the entire system.

7.1.2.4 IoT Sensorial Middleware

The IoT Sensorial Middleware is responsible for managing raw data collected from IoT devices or data provided by APIs. It processes this data by performing tasks such as filtering out irrelevant or noisy information, aggregating multiple data points, and validating the data. The pre-processed data is forwarded to the Common Information Model, where it undergoes further standardization and integration into the broader system. This ensures the data is ready for consistent use across all system components.

7.1.3 Component Diagram

The following figure illustrates the key modules (green colour) of “IML” and the interactions with other components and tools.

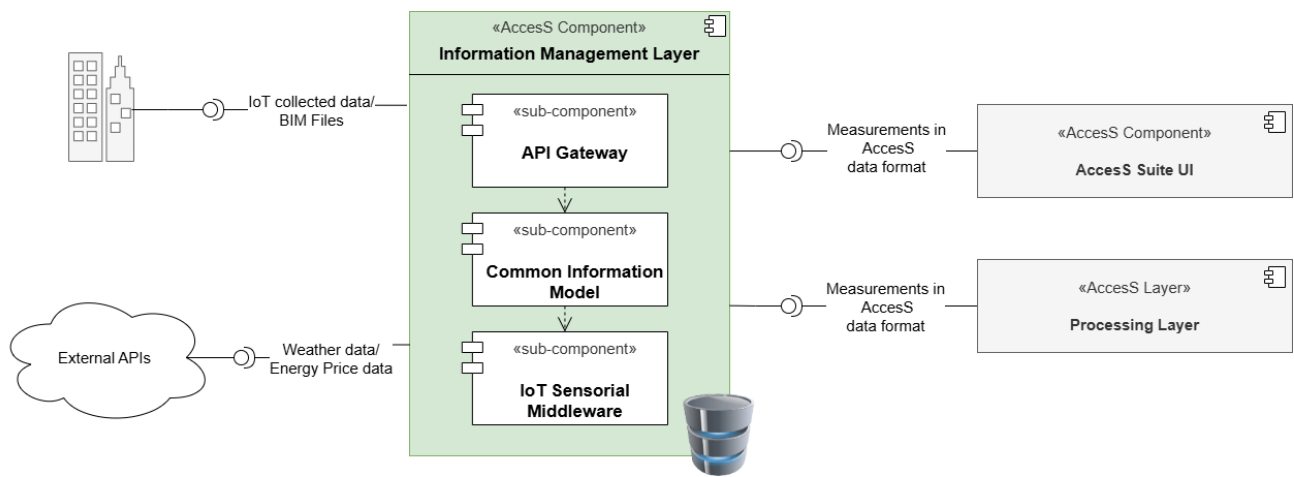


Figure 23. IML Component Diagram

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 8 Interfaces of IML

Interface	R/W	Description
Database	R/W	Stores all collected and processed data, supporting queries and updates by authorized system components.
API Gateway	R/W	Manages and forwards data requests between components while ensuring secure and restricted database access.
Processing Layer	R/W	Receives standardized data from the Information Management Layer.
IoT Middleware	R	Retrieves energy and building condition data from building infrastructure using open standards and communication protocols.

7.2 Energy Efficient and Sustainable Design Tool

7.2.1 High-level description

The Energy Efficiency and Sustainable Design Tool (EESDT) is a comprehensive platform designed to enhance building energy performance by facilitating the evaluation and optimization of renovation scenarios. It begins with the Baseline Scenario Generator, which allows users to upload the building's as-is openBIM data and generates both baseline and benchmark energy performance scenarios based on the building's unique characteristics. The What-If Scenarios Generator builds on this by creating multiple renovation options according to user preferences, incorporating data from the Generic Assets and Appliances Catalogue and the Sensorial and Smartification Products Catalogue. The BEP Simulation Engine then evaluates the energy performance of these scenarios using EnergyPlus, calculating key performance indicators (KPIs) for both baseline and renovation scenarios. To optimize renovation strategies, the Renovation Scenarios Optimization Engine performs multi-criteria analysis, proposing cost-effective solutions based on available resources, desired outcomes, and data from the two catalogues. The user interacts with the tool via the EESDT UI, which provides a user-friendly interface for selecting renovation measures, viewing KPI results, and comparing optimized solutions to the original baseline, enabling informed decision-making on energy-efficient building renovations.

7.2.2 Subcomponents

The subsequent subsections provide an overview of the individual subcomponents that make up the EESDT. Each subcomponent is designed to perform specific functions that together enhance the tool's ability to assess building energy efficiency.

7.2.2.1 Baseline Scenario Generator

The **Baseline Scenario Generator** allows users to upload a building's baseline (as-is) openBIM data in IFC format. This subcomponent is responsible for reviewing the building's current state and generating two scenarios: the baseline scenario, which represents the minimum enhancement of the building's

energy performance, and the benchmark scenario, which reflects the maximal enhancement potential. Both scenarios are contextualized based on the building's specific characteristics and environment, providing a foundation for further energy performance evaluations and renovation planning.

7.2.2.2 What-If Scenarios Generator

The **What-If Scenarios Generator** is responsible for creating potential renovation scenarios. This tool takes the building's initial BIM model (baseline IFC file) and the end-user's renovation preferences, generating multiple renovation options for evaluation. For each scenario, a modified IFC file is produced, embedding all proposed materials and components for renovation. It communicates with the Generic Assets and Appliances Catalogue and the Sensorial and Smartification Products Catalogue to gather information on the necessary materials, components, and energy conservation measures to improve the building's energy efficiency. Once completed, each renovation scenario is saved, which then triggers the energy performance evaluation process.

7.2.2.3 BEP Simulation Engine

The **Building Energy Performance (BEP) Simulation Engine** is tasked with evaluating the energy performance of both baseline and renovation scenarios by calculating predefined energy-related key performance indicators (KPIs). Using EnergyPlus as the core simulation tool, the engine provides accurate assessments of a building's energy efficiency, enabling users to compare the impacts of various renovation measures on overall energy performance. This subcomponent is also responsible for generating the input data needed for the energy simulation program, by converting the IFC files into specific simulation input data files (IDF).

7.2.2.4 Renovation Scenarios Optimization Engine

The **Renovation Scenarios Optimization Engine** is an advanced toolkit designed to perform multi-criteria analysis, combining various factors to propose the most cost-effective renovation solutions. This engine takes into account the building's specific, and potentially limited, resources and uses data from the two key catalogues: one detailing generic assets and appliances (e.g., energy consumption, efficiency class), and another focusing on sensorial and smartification products (e.g., energy metering, IAQ monitoring). Additionally, the optimization process considers commonly desired enhancement outcomes or goals, ensuring the proposed solutions align with both performance and budgetary constraints.

7.2.2.5 Generic Assets and Appliances Catalogue

This subcomponent compiles a template catalogue listing generic building assets and appliances, along with their key properties, such as mean energy consumption, energy generation, energy efficiency class, and other relevant performance metrics. This catalogue provides essential data for energy performance evaluations and helps inform decisions on appliance selection during renovation planning.

7.2.2.6 Sensorial and Smartification Products Catalogue

This subcomponent compiles a template catalogue of sensorial and smartification products, detailing their primary functionalities and smartification potential. It includes products such as energy consumption meters and indoor air quality (IAQ) measurement devices, as well as their associated costs for procurement, installation, and operation. This catalogue supports the integration of smart technologies into renovation scenarios to improve energy management and building efficiency.

7.2.2.7 EESDT UI

The **EESDT UI** serves as the front-end interface through which users interact to view building characteristics, renovation options, and energy-related KPIs. Users provide the baseline IFC file. Through this interface, users can select renovation measures, triggering the What-If Scenarios Generator to create updated IFC files. Once the proposed measures are simulated by the BEP Simulation Engine, the UI retrieves the corresponding KPI values and presents them to the user. The UI can also illustrate optimization results to compare the performance of all Pareto-efficient solutions against the baseline, allowing for a clear assessment of how each solution improves upon the initial state.

7.2.3 Component Diagram

The following figure illustrates the key modules (green colour) of “EESDT” and the interactions with other components and tools.

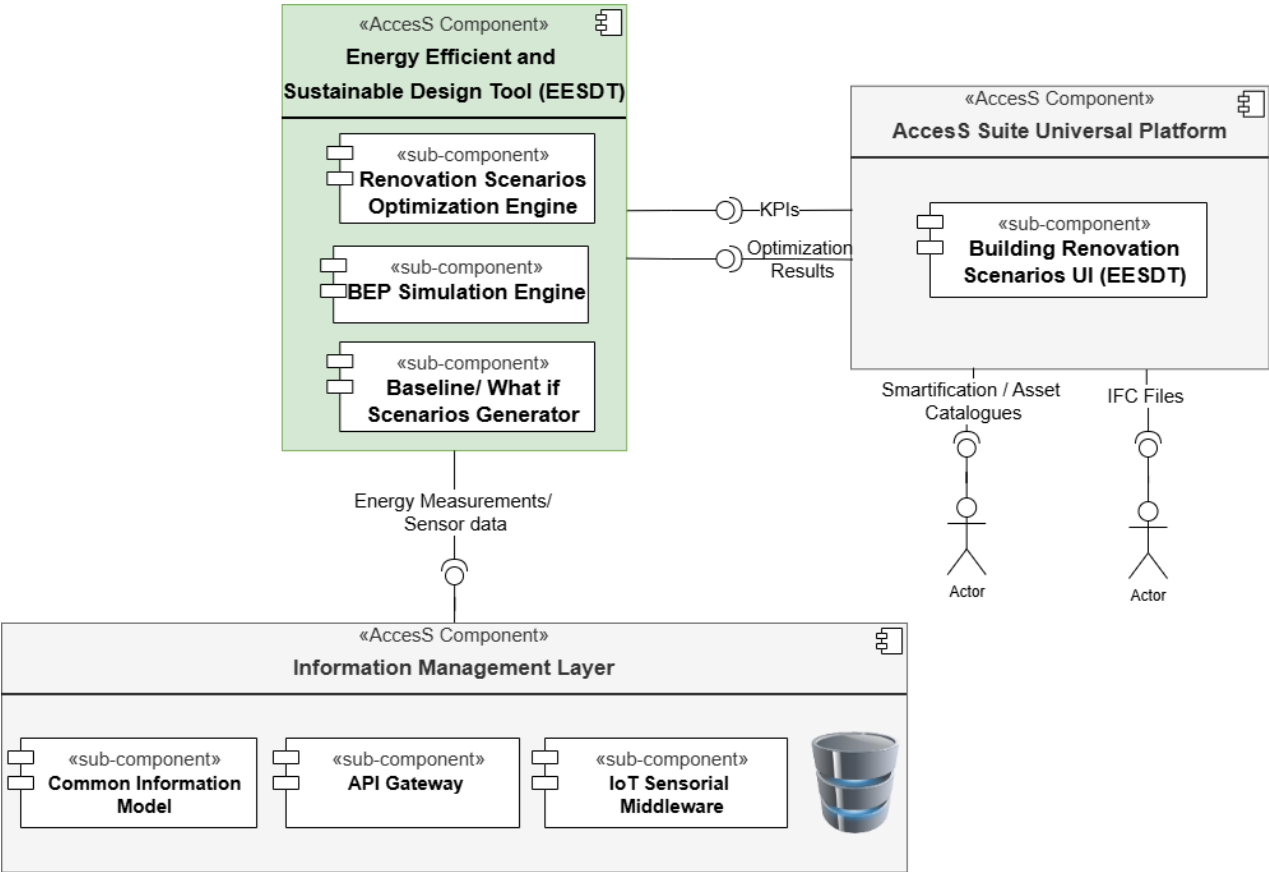


Figure 24. Energy Efficient and Sustainable Design Tool Component Diagram

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 9. Interfaces of Energy Efficient and Sustainable Design Tool

Interface	R/W	Description
Information Management Layer (IoT Middleware)	R	Retrieves operational data from building infrastructure using open standards and communication protocols.
EESDT UI	W	Visualizes renovation scenarios, KPIs, and Pareto efficient solutions.

7.3 Energy Comfortness Tool

7.3.1 High-level description

The Energy Comfortness Tool (ECT) to be developed under T4.2 offers a holistic approach to optimizing energy efficiency while maintaining occupant comfort. By introducing the concept of "energy comfortness," it uses sensor data, machine-learning and conventional models to evaluate thermal, acoustic and visual comfort, as well as Indoor Air Quality (IAQ), by considering the needs and features of the occupants. This assessment is tied to energy efficiency; through modelling of comfort's impact to energy, the tool allows users to simulate and monitor occupant comfort levels and their impact on an indoor space's energy, enabling dynamic, data-driven adjustments that enhance both comfort and energy efficiency.

7.3.2 Subcomponents

The following sections aim to provide a detailed breakdown of the individual sub-components that constitute the Energy Comfortness Tool (ECT). Each sub-component offers specific functionalities that collectively contribute the tool's capability to evaluate the energy efficiency and sustainability of the buildings. ECT provides a framework to optimize energy use in smart buildings while ensuring comfortable indoor conditions across thermal, acoustic, visual, and air quality dimensions. Using real-time data from sensors and data-driven modelling, it simulates and monitors comfort levels, responding flexibly to changing conditions to balance comfort and energy efficiency. With its reliance on Machine-Learning (ML) and BIM-based simulations, the tool delivers actionable insights on how different comfort parameters impact energy use, helping buildings adapt to more suitable conditions for their occupants. ECT introduces a new approach to indoor building comfort that incorporates a multitude of factors: (1) thermal, (2) acoustic, (3) visual and (4) Indoor Air Quality (IAQ). "Comfortness" consists of these elements and is evaluated on the basis of energy efficiency. Therefore, ECT not only issues indoor environment quality metrics but also models their impact on energy performance. The innovative integration of ML covers limitations to the traditional approach of BIM simulators, as their heuristic character accounts for any unforeseen variable in conventional models. At the same time, integration of BIM simulations ensures the robustness and generalizability of the tool, to cover the diverse use-cases.

7.3.2.1 Energy Comfortness Engine

Energy Comfortness Engine (ECE) focuses on estimating comfort and energy conditions in an indoor space (e.g., a room). It gathers aggregated data from sensors that measure factors like indoor temperature, luminance, noise levels and concentration of air quality features. By feeding this information into Machine-Learning (ML) models, ECE evaluates how comfortable the environment is

for occupants, based on their profile (e.g., age, metabolic rate, clothing). The ML models interact with BIM-based simulations to maintain a current, accurate view of the space and accommodate changes in architectural designs. This way, heuristic models and deterministic simulations work in tandem to provide the optimal estimate of indoor comfortness and its impact on energy consumption.

ECE is designed to model indoor comfort conditions under various scenarios while evaluating the resulting energy consumption. It leverages BIM data to create a digital overview of comfort levels and energy consumption within the space of interest. Users can simulate comfort features, including thermal, acoustic, visual, and air quality aspects, to understand how these affect both occupant well-being and energy efficiency. ML models are integrated to refine conventional simulations, enhancing their ability to handle complex and variable conditions. This dual approach ensures that both immediate and long-term impacts on energy performance are accurately assessed. The tool outputs insights into optimal comfort-energy trade-offs, enabling architects and engineers to make well-informed decisions that balance occupant satisfaction with sustainable energy use. The engine workflow is as follows:

1. User Configuration: Users provide BIM-based building data (in IFC format) and define simulation parameters and occupant profiles. This sets the stage for modelling specific comfort entities within the environment.
2. Feature Processing: Environmental and architectural features from BIM models are processed and prepared, ensuring that all relevant building properties (e.g., materials, spatial layout) are accurately represented for simulation. The space of interest and its properties are isolated to be fed to the models. Moreover, aggregated input data are collected from the database and are prepared for the ML models.
3. Comfort Level Modelling: Comfort simulation includes two families of models: (a) conventional simulation and (b) ML models. Model selection occurs at a per feature case, as different nature of environmental behavior has different requirements.
4. Energy Impact Assessment: Based on the configuration of comfort modelling and the comfort levels estimated, the expected energy consumption is estimated.

7.3.2.2 Energy Comfortness Dashboard

The Energy Comfortness Dashboard (ECD) is the entry point for users to access the tool. The active dashboard is essential for user interaction, as the main stakeholders (e.g. civil engineers) require a no-code, intuitive, interface that ensures ease-of-use. The sub-component offers visual feedback on comfort levels and energy usage that enables immediate decision-making, as the users can identify potential sources that lower comfort within the building or increase energy consumption (e.g. material components of the building's façade with inadequate thermal insulation). This way, users can have a concise view of the pragmatic performance of the building and continue with changes for improving either comfortness or energy efficiency. Comprehensive graphs provide temporal changes of energy comfortness to identify transient or periodic trends and depictions between comfort and energy consumption, to facilitate the recognition of comfort factors that affect energy more. Through visualization of eXplainable Artificial Intelligence (XAI) analysis performed on models, the user will be able to instantly understand the degree of contribution of each comfort feature to energy performance.

7.3.3 Component Diagram

The following figure illustrates the key modules (green colour) of “**Energy Comfortness Engine**” and the interactions with other components and tools.

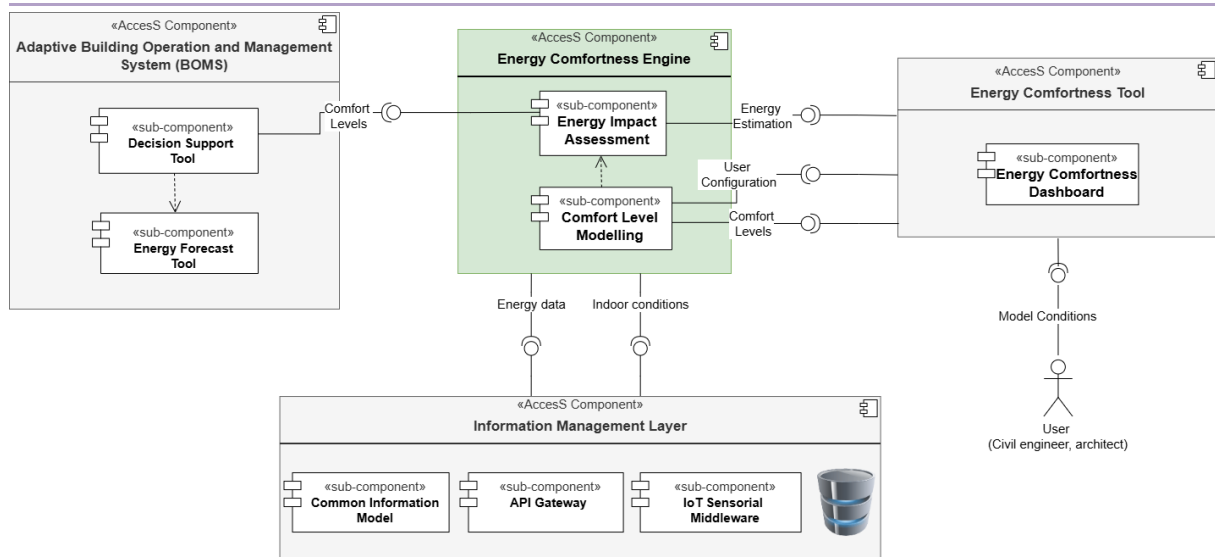


Figure 25. Component Diagram of the Energy Comfortness Tool

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 10. Interfaces of Energy Comfortness Tool

Interface	R/W	Description
Information Management Layer (IoT Middleware, Database)	R	Retrieves operational data from building infrastructure using open standards and communication protocols.
Energy Comfortness Dashboard	R	Accesses the initial configuration parameters related to various comfort aspects.
Energy Comfortness Dashboard	W	Displays comfort levels and related energy efficiency KPIs
Adaptive Building Operation and Management System (BOMS)	W	Provides comfort levels to the BOMS tool, integrating it into the optimization process.

7.4 ErgoFlow

7.4.1 High-level description

This component aims at enhancing tools and aiding in the design and evaluation of ergonomically adapted products. Specifically, it focuses on offering designers and manufacturers tools to ensure that their products meet ergonomic standards, providing comfort, accessibility, and safety for all users, including those with disabilities and elderly adults.

7.4.2 Subcomponents

The ErgoFlow tool is divided into two main subcomponents: the ErgoFlow Evaluation Tool and the ErgoFlow Library. Together, these two components enable a comprehensive approach to creating and evaluating ergonomically adapted products that prioritize comfort and usability for all users, particularly those with specific accessibility needs.

7.4.2.1 ErgoFlow Evaluation Tool

The aim of this subcomponent is to offer testing functionalities that assess the ergonomics, accessibility, and user comfort of furniture designs. Designers, architects, and product developers can upload 3D models of furniture to the ErgoFlow tool, where the system analyzes the models and generates a report that evaluates their ergonomic compliance, comfort, and accessibility. The tool also checks for adherence to EU safety standards and provides design recommendations to improve the product's ergonomics and usability, ensuring it meets the needs of individuals with disabilities and elderly adults.

7.4.2.2 ErgoFlow Library

This subcomponent provides access to a library of furniture items that have been evaluated according to ergonomic principles and usability standards. Designers can browse the collection of 3D models, download items, and incorporate them into their projects or Building Information Modeling (BIM) scenarios. The library supports both the upload and download of 3D models of ergonomic furniture based on specific project requirements and use cases, helping designers efficiently integrate ergonomically compliant products into their designs.

7.4.3 Component Diagram

The following figure illustrates the key modules (green colour) of “**ErgoFlow**” and the interactions with other components and tools.

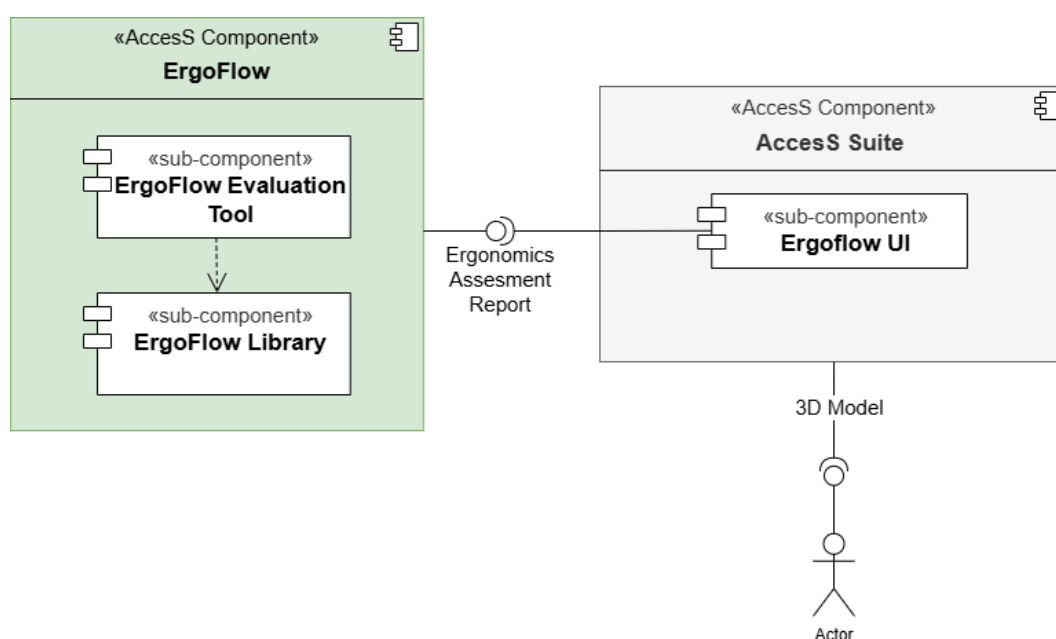


Figure 26. Component Diagram of ErgoFlow Tool

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 11 Interfaces of ErgoFlow

Interface	R/W	Description
ErgoFlow UI	R	Upload 3D furniture models for evaluation.
ErgoFlow Evaluation Tool	W	Generates ergonomics assessment reports with recommendations and compliance checks.
ErgoFlow Library	R/W	Provides a library of ergonomic 3D models for browsing, downloading, and uploading.

7.5 Virtual User Models and VUM-based Virtual Humans

7.5.1 High-level description

This component aims at developing Virtual User Models (VUMs) to represent aging individuals and people with disabilities. These models will integrate anthropometric data and human factors to assess and improve accessibility in digital and physical environments. A graphical user interface (GUI) will allow users to create and edit these models, which will be used to generate Virtual Humans (VHs) for simulating and evaluating accessibility in 3D environments.

7.5.2 Subcomponents

The following sections aim to provide a detailed breakdown of the individual sub-components that constitute the Virtual User Models and VUM-based Virtual Human tool. Each sub-component does specific functionalities that collectively contribute the tool's capability to create 3D model of VH based on the configured VUM.

7.5.2.1 VUM Digital Authoring Tool

The editor provides an intuitive, user-friendly interface for configuring user model parameters in accordance with the VUM (Virtual User Model) specification. This specification offers a detailed semantic representation of anthropometric data and other characteristics, such as mobility limitations, posture, and physical attributes, which describe aging individuals and people with disabilities.

7.5.2.2 VH Generator

Using the VH Generator, users (or actors) can customize these parameters to accurately reflect the characteristics of the target population. Once the user models are fully configured, the tool generates Virtual Humans (VH), which are precise digital avatars of the specific VUMs in a 3D environment. These

Virtual Humans are crucial for simulations, testing, and other use cases that require realistic representations of how diverse individuals interact in a virtual space.

7.5.3 Component Diagram

The following figure illustrates the key modules (green colour) of the “**Virtual User Models and VUM-based Virtual Humans**” and the interactions with other components and tools.

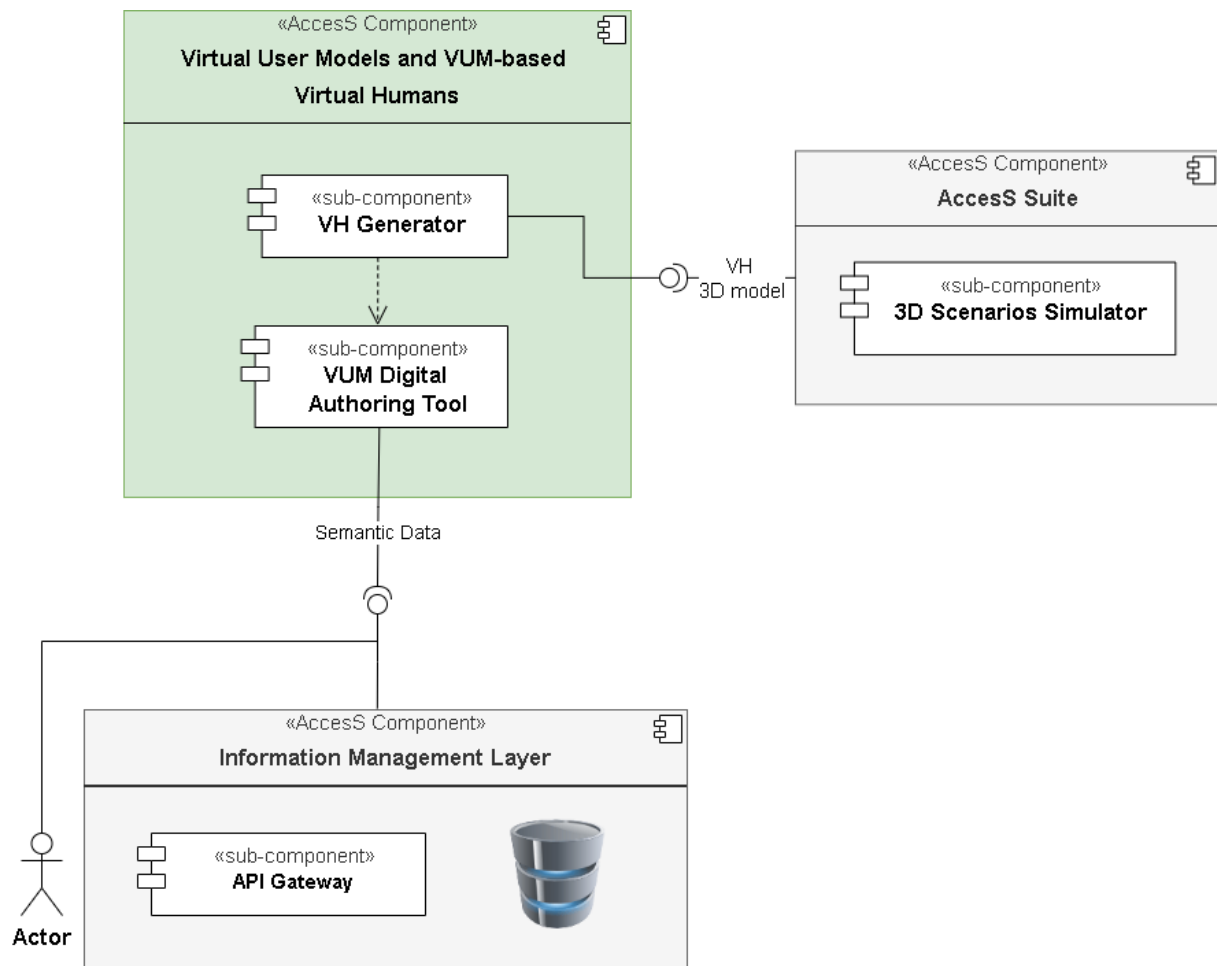


Figure 27. Component Diagram of VUM Authoring Tool

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 12 Interfaces of VUM

Interface	R/W	Description
Information Management Layer	R	Read from the graph database the semantic data
3D Scenarios Simulator	W	Export VH 3D models

7.6 3D Scenarios Simulator

7.6.1 High-level description

The 3D Scenarios Simulator serves as the central component of the pipeline, orchestrating the synthesis of 3D environments, the integration of virtual humans, and the generation of simulation scenarios. It is composed by four interconnected sub-components, each handling a specific aspect of the simulation process.

7.6.2 Subcomponents

7.6.2.1 3D Environment Generator

The 3D Environment Generator creates the foundational virtual environment using input data such as IFC files, which represent architectural models, or 360-degree photos that capture real-world spaces. This sub-component transforms the raw input data into detailed 3D models, forming the basis for the simulation environment. These models provide a realistic setting for the scenarios and interactions that follow.

7.6.2.2 3D Environment Integration Manager

The 3D Environment Integration Manager enhances the 3D environment generated by the previous component to make it interactable by the virtual humans. This involves modifying the environment to include features such as interactable objects, pathways, and barriers. These modifications are guided by the specific requirements of the virtual humans generated in the pipeline, ensuring that all environmental elements are compatible with their movement, dynamics and interaction capabilities.

7.6.2.3 VUM Integration Manager

The VUM Integration Manager handles the integration of virtual human (VH) models into the simulated environment. By utilizing anthropometric data from the VH Generator, this sub-component simulates the movement, behavior, and dynamics of virtual humans within the scene. It ensures that the VHS can realistically navigate the environment, interact with objects, and respond to the scenario goals.

7.6.2.4 Scenario Generator

The Scenario Generator designs simulation scenarios by combining the 3D environment and virtual human models. It defines the objectives, tasks, and paths for virtual humans, creating realistic use cases within the environment.

7.6.3 Component Diagram

The following figure illustrates the key modules (green colour) of the “**3D Scenarios Simulator**” and the interactions with other components and tools.

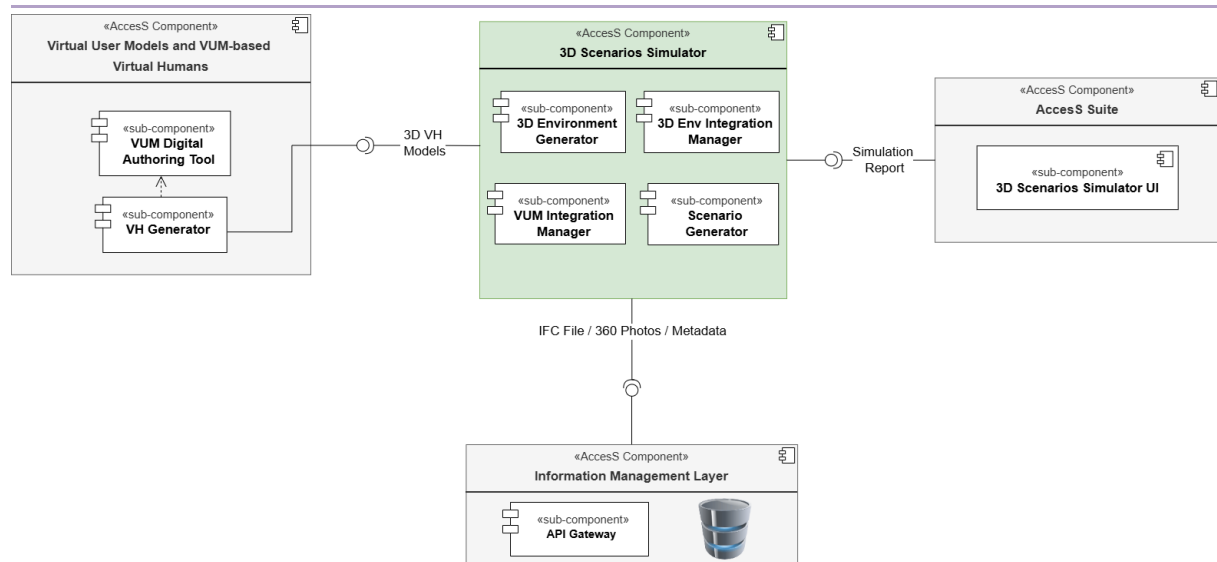


Figure 28. Component Diagram of 3D Simulation Engine

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 13 Interfaces of 3D Scenarios Simulator

Interface	R/W	Description
Virtual User Models and VUM-based Virtual Humans	R	Read 3D environments from a pool
Virtual User Models and VUM-based Virtual Humans	R	Read 3D VH models
3D Scenarios Simulator	W	Report simulation results

7.7 Advance Building Operation and Management Systems (BOMS)

7.7.1 High-level description

This tool is intended to improve building energy efficiency by dynamically balancing comfort levels, user behavior patterns, and cost savings. It incorporates forecasting models to provide predictions about energy generation and consumption based on user behavior, environmental factors, and historical data. By utilizing these projections, it offers practical suggestions for maximizing energy efficiency, cutting expenses, and upholding high occupant comfort standards.

7.7.2 Subcomponents

7.7.2.1 Energy Forecasting Tool

This subcomponent forecasts energy prices, renewable energy generation, and energy consumption using Machine Learning and Deep Learning models. It gives users accurate insights that enable them to optimize energy production and consumption plans by combining real-time inputs with historical data analysis.

Among the tool's primary characteristics are:

- Renewable Energy Generation: Forecasts renewable energy generation, by analyzing weather data and system performance parameters.
- Energy Consumption: Forecasts energy demand analyzing the building's demand patterns
- Price forecasting: Forecasts energy prices using past pricing information and market trends, allowing for well-informed decision-making.

7.7.2.2 Decision Support Tool

The Decision Support Tool is a sophisticated solution designed to optimize energy usage and renewable energy generation while maintaining a balance between cost efficiency and occupant comfort. By leveraging predictive analytics, the tool forecasts future energy demand, renewable energy output, and energy prices using a combination of historical data, real-time inputs, and advanced machine learning models.

By combining forecasting results with real-time interior environment monitoring, its adaptive capabilities enable it to react dynamically to changing conditions. This guarantees that energy strategies maintain ideal thermal, visual, and air quality criteria while maximizing efficiency and preserving comfort levels. Through feedback loops, the tool continuously improves its forecasts and decision-making procedures, allowing it to change and adjust over time to new usage trends and environmental conditions.

The application emphasizes actionable insights and offers simple suggestions, such as modifying energy consumption patterns, maximizing the use of renewable energy sources, or modifying system activities to coincide with energy-efficient times. Forecasting, real-time control, and comfort-aware optimization are seamlessly integrated, enabling users to attain sustainable energy management without sacrificing occupant well-being.

7.7.2.3 GIS Visualisation

The BOMS tool will be GIS-supported for the location-specific management of accessibility features. The addition of location-specific features in GIS environment will support the transformation of urban environments into accessible and inclusive spaces for people with disabilities by allowing the utilization of rich visual representations and geographic information for enhanced decision-making. RE GIS has capabilities to enable optical detection of location-specific features in 3D maps.

7.7.3 Component Diagram

The following figure illustrates the key modules (green colour) of “BOMS” and the interactions with other components and tools.

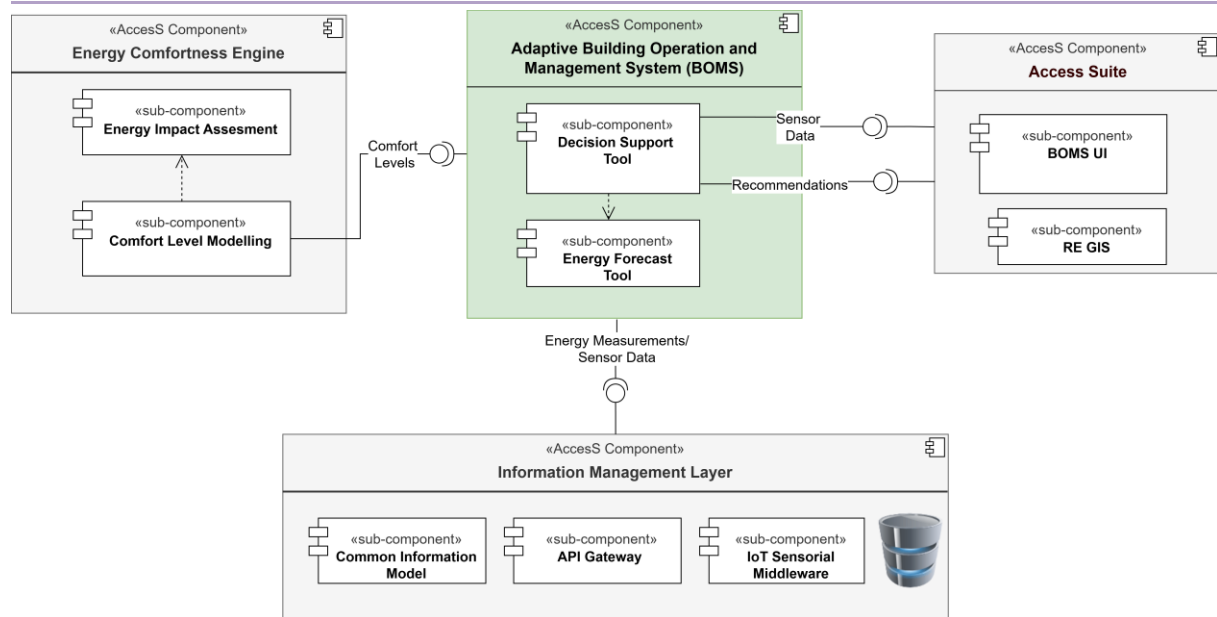


Figure 29. BOMS Component Diagram

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 14 Interfaces of BOMS

Interface	R/W	Description
Information Management Layer	R	Read measurements from the database
Energy Comfortness Engine	R	Read comfort levels
Information Management Layer	W	Write forecasts to database
Information Management Layer	W	Write optimization results to database
Information Management Layer	W	Write KPIs results to database
Information Management Layer	W	Write geolocation data of accessibility features to database

7.8 EV Charging Optimizer

7.8.1 High-level description

The Integrated e-Mobility service of the AccesS project focuses on transforming electric vehicles (EVs) into active elements within building infrastructures. The primary objective is to develop an inclusive

and accessible EV charging infrastructure that caters to the needs of all users, particularly people with disabilities and the elderly. This involves analyzing user behaviors, identifying accessibility requirements, and integrating these considerations into charging schedule optimizations. By leveraging predictive algorithms and smart charging systems, the project aims to enhance charging efficiency, minimize strain on the electrical grid, and ensure equitable access to charging facilities for users with accessibility needs.

7.8.2 Subcomponents

The EV Charging Optimizer component within the AccesS Suite comprises several technical subcomponents designed to enhance the inclusivity and efficiency of the EV charging infrastructure. These subcomponents focus on developing and implementing predictive algorithms, integrating smart charging systems with accessibility features, evaluating algorithm performance, balancing energy demands with supply, and manipulating data to support these functionalities.

7.8.2.1 Charging Sessions Forecasting Algorithms

This subcomponent focuses on creating predictive algorithms that optimize charging behaviors to accommodate all users, especially those with accessibility needs. By analyzing aggregated charging session data—such as station usage patterns, session durations, and power consumption metrics—the algorithms identify trends and correlations without relying on individual user identifiers. The goal is to forecast optimal charging times and durations, enabling the system to dynamically adjust to varying usage patterns. This enhances the responsiveness of the charging infrastructure, reduces wait times, and minimizes energy waste, ensuring efficient operation for all users.

7.8.2.2 Smart Charging System with accessibility features

Building upon the predictive algorithms, this subcomponent involves implementing advanced smart charging systems that integrate specific accessibility features. The system prioritizes charging sessions for users with disabilities and the elderly by defining preferred charging windows, typically during daylight hours, to maximize convenience and safety. Real-time data is utilized to manage and allocate charging resources effectively, supporting adaptive scheduling that responds to changes in demand and user availability. This ensures that accessibility users receive reliable service without compromising the overall efficiency of the charging infrastructure.

7.8.2.3 Energy Optimization System

Effective energy management is critical to prevent grid overloads and maintain sustainable operation of the EV charging infrastructure. This subcomponent employs advanced forecasting techniques to predict energy consumption patterns of the EV fleet. By aligning charging schedules with periods of high energy availability, the system implements strategies such as load shifting and demand response. This distributes energy usage more evenly throughout the day, reducing peak demand pressures on the electrical grid. The balancing mechanism ensures that the charging infrastructure remains robust and capable of supporting a growing number of EVs while maintaining grid stability.

7.8.3 Component Diagram

The following figure illustrates the key modules (green colour) of “EV Charging Optimizer” and the interactions with other components and tools.

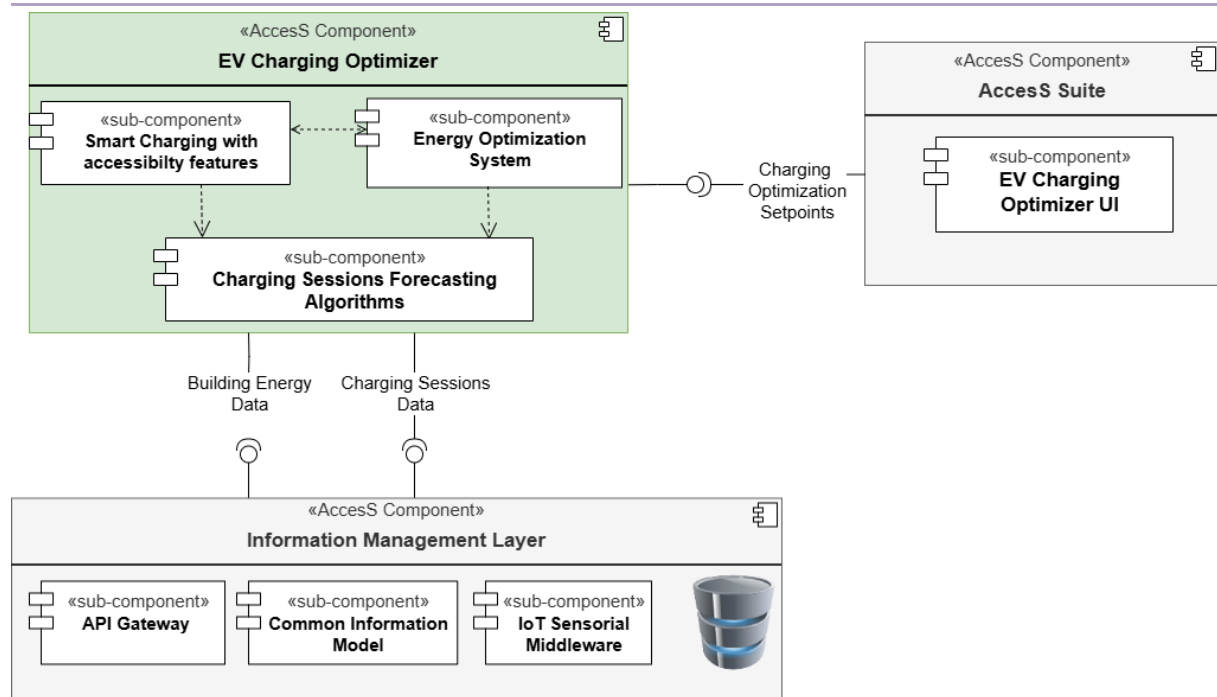


Figure 30. Component Diagram of e-Mobility

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 15 Interfaces of EV CHargins Optimizer

Interface	R/W	Description
Information Management Layer	R	Read energy prices
Information Management Layer	R	Read building energy data
EV Charger	R	Read SoC
Information Management Layer	W	Charging optimization setpoints

7.9 Universal Accessibility Assessment Tool

7.9.1 High-level description

This tool is designed to evaluate accessibility features on a large scale. It interfaces with the AccessS Suite and generates accessibility assessment reports based on user input.

7.9.2 Subcomponents

The Universal Accessibility Assessment Tool operates as a single integrated component within the Large-Scale Accessibility system. It handles both the processing of user input and the generation of accessibility assessment reports, serving as the core assessment engine for the Suite.

7.9.3 Component Diagram

The following figure illustrates the key modules (green colour) of “the **Universal Accessibility Assessment Tool**” and the interactions with other components and tools.

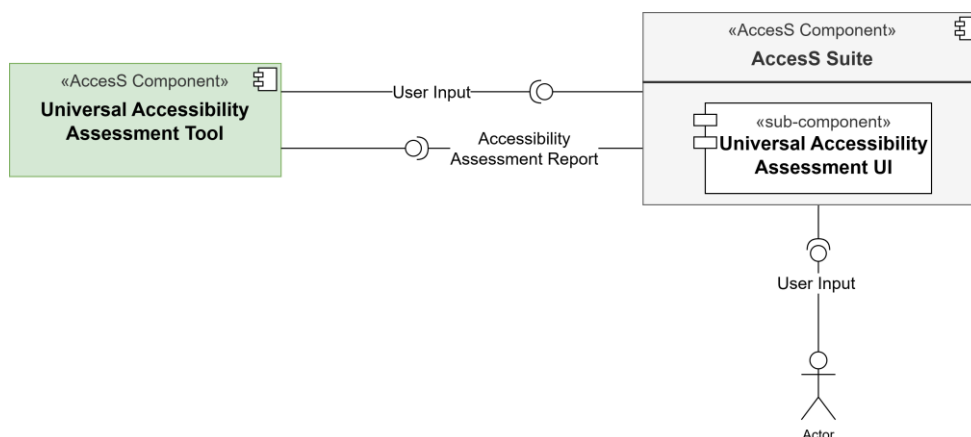


Figure 31. Component Diagram of Large Accessibility Assessment Framework

The table below describes the interfaces of the component and the read/write (R/W) interactions with other components.

Table 16 Interfaces of Universal Accessibility Assessment Tool

Interface	R/W	Description
Universal Accessibility Assessment Tool	R/W	Receives user-provided data for accessibility assessment processing and provides the generated accessibility evaluation results and findings.
Large Scale Accessibility Assessment UI	R/W	Sends the user provided data to the accessibility assessment tool and displays the generated report.

7.10 AccessS Suite

7.10.1 High-level description

The **AccessS Suite** is the the main platform for managing all components, interfaces, and services within the system. It is a modular, customizable platform that connects the processing, representation, and information management layers, facilitating communication between all system components. The

Suite is designed to work with different platforms, devices, and communication protocols, ensuring compatibility across various environments. It is specifically designed with a focus on accessibility, making it easier for individuals with disabilities and older persons to use and navigate the system. The AccesS Suite will undergo testing and refinement to ensure its functionality and readiness for pilot deployments (T7.3).

7.10.2 Subcomponents

7.10.2.1 Web Server

This subcomponent provides a web-based interface for users to interact with the system. It facilitates the access to recommendations, key performance indicators (KPIs), accessibility reports, and other services. Additionally, the interface supports smooth navigation between different system modules or applications through seamless redirection, ensuring a user-friendly experience.

7.10.2.2 User Authentication

This subcomponent handles the verification of user credentials and manages secure access to the Suite. It enforces role-based access control, allowing users to access data and functionalities based on their permissions. Additionally, it integrates with authentication protocols to maintain a secure and user-specific environment.

7.10.3 Component Diagram

The following figure illustrates the key modules (green colour) of the “AccesS Suite” and the interactions with other components and tools.

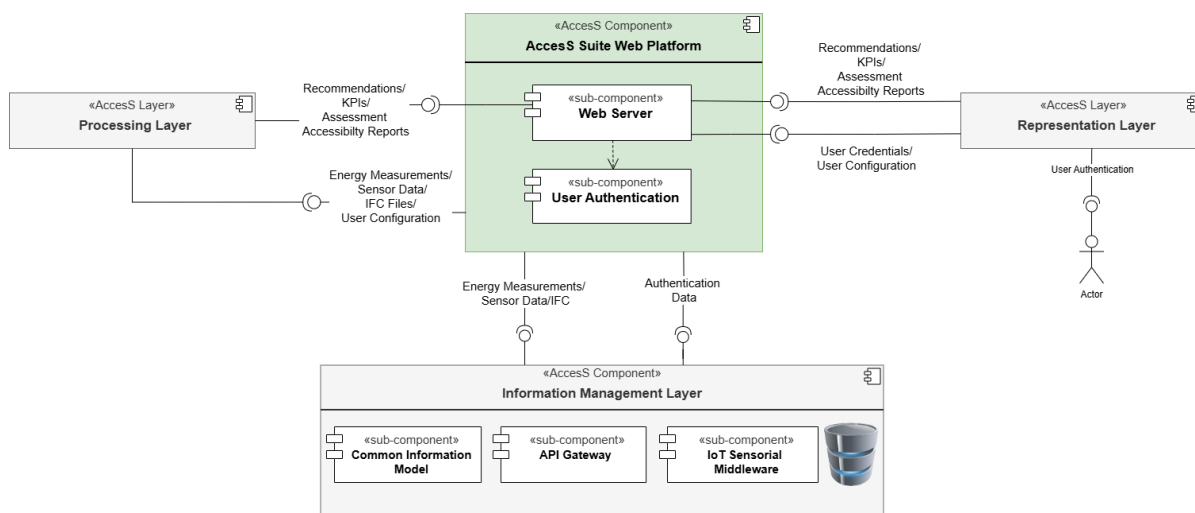


Figure 32 AccesS Suite Web Platform Component Diagram

Table 17 Interfaces of AccesS Suite Web Platform

Interface	R/W	Description
Web Server	R/W	Provides the web interface for users to interact with system features, including

		recommendations, KPIs, and reports, and redirects to other project UIs.
User Authentication	R/W	Handles user login, authentication, and role-based access to ensure secure system entry. Manages permissions and integrates with external authentication services.
Information Management Layer	R/W	Provides measurements retrieved from sensors, including energy measurements, sensor data, and IFC files, stored in the central database for processing.
Processing Layer	R/W	Includes a suite of digital tools that process user inputs and measurements (e.g., energy data, sensor data) to generate recommendations, KPIs, and accessibility reports. It sends the generated outputs to the Web Server for visualization and further interaction.
Representation Layer	R/W	Consists of interfaces where the results (e.g., recommendations, KPIs, accessibility reports) are visualized and user configurations are managed..

8 Deployment View

The high-level deployment diagram below illustrates the system’s architecture, showcasing the distribution of various software components across multiple servers. Each component provides essential functionalities to support tasks such as energy efficiency, accessibility assessments, simulation environments, and building operations. However, because many tools are developed as standalone applications, each requires deployment on its own dedicated server along with its corresponding user interface. However, all servers are interconnected through the central AccesS Suite Server, which hosts the AccesS Suite Web Platform. This platform serves as a gateway, enabling users to access the interfaces of all other tools via redirection.

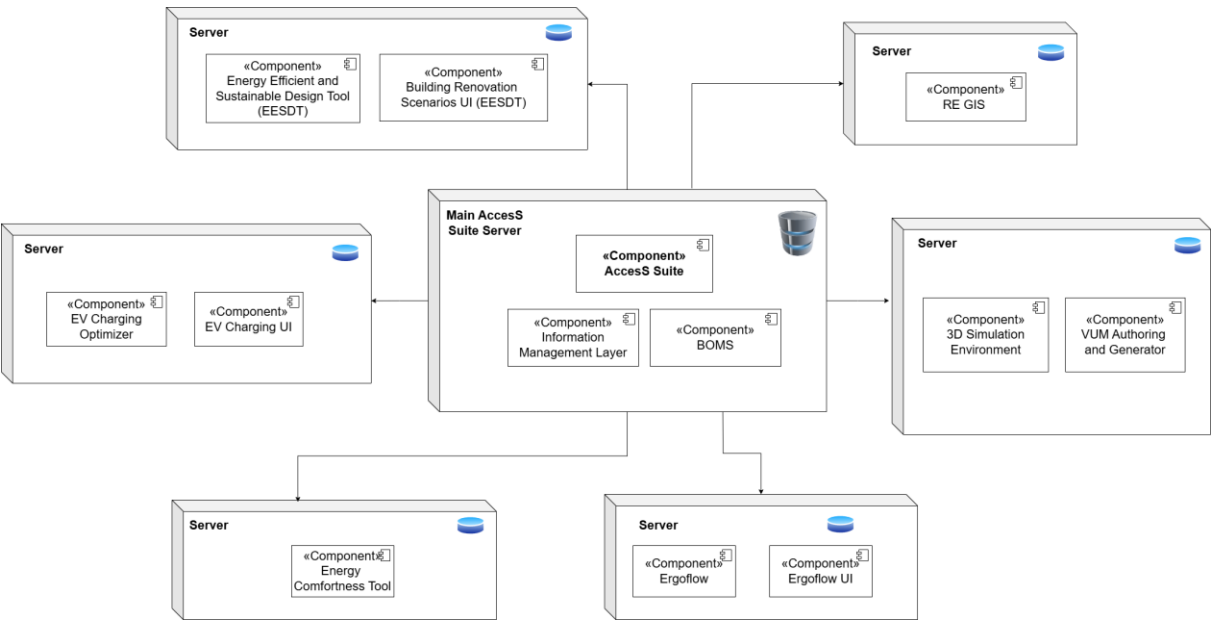


Figure 33. AccesS High Level Deployment Diagram

The table below provides a detailed overview of each component from the deployment diagram. It highlights essential information such as ownership, associated tasks, deployment requirements, and system interactions. This breakdown clarifies responsibilities, identifies resource needs, and supports the efficient maintenance and management of the overall infrastructure.

Table 18. Hardware requirements foreseen for the Deployment of the Access Tools

Component	Owner	Associated Task(s)	Hardware/Software Requirements	Interaction
Access Universal Platform UI, Information Management Layer, BOMS	CERTH	T6.1/T7.2	- 8-core CPU - 32 GB RAM - 1 TB storage - Linux - PostgreSQL - Docker	Central server hosting the main platform, database, and management layer. Facilitates integration with all connected tools.
Energy Efficient and Sustainable Design Tool, Building Renovation Scenarios UI	QUE	T4.1	- 8-core CPU - 32 GB RAM - 1 TB storage - EnergyPlus	Access Suite
Energy Comfortness Tool	UNIS	T4.2	- 8 CPU, - 32GB RAM - 1 TB storage - Linux - PostgreSQL - Docker	Information Management Layer, BOMS, Access Universal Platform UI
ErgoFlow UI, ErgoFlow	CETEM	T4.3	- 8-core CPU - 32 GB RAM - 1 TB	Access Suite
VUM 3D Simulation Environments UI, 3D Simulation Environment, VUM Authoring and Generator	CERTH/FOR TH	T5.1/T5.2	- 8-core CPU - 32 GB RAM - 1 TB - 4080 RTX GPU - Unity - Matterport	Access Suite

RE GIS Dashboard	DMO	T6.1	- 4 cores - 16 GB RAM - 20 GB storage - Windows, - MS SQL Server - GeoServer - IIS - NET Framework 4.8	Access Suite
EV Charging Optimizer, EV Charging UI	HIVE	T6.3	- 8-core CPU - 32 GB RAM - 1 TB	Access Suite

9 Information View

This diagram represents the Information View of AccesS Suite system, showcasing the flow of data between various components. It highlights how information is collected, processed and utilized across different stages to optimize energy efficiency and user comfort while enabling the creation of simulation environments.

The data flow begins with raw measurements from various sensors, which are processed through an IoT sensorial middleware and stored in the central database. When tools and applications need access to this data, an API gateway manages communication, ensuring secure and efficient data retrieval and delivery.

Key components, including the tools that are related to the buildings operation, utilize this processed data to provide insights, optimization results, and KPIs. Additionally, at a higher level, the VUM 3D simulation environment leverages IFC files to simulate the building environment, and through the VUM Digital Authoring tool, it examines the building in accordance with human activity. Meanwhile, ErgoFlow retrieves the furniture model and evaluates it based on accessibility features. Their outputs are integrated and displayed within the AccesS Suite platform for visualization and further analysis.

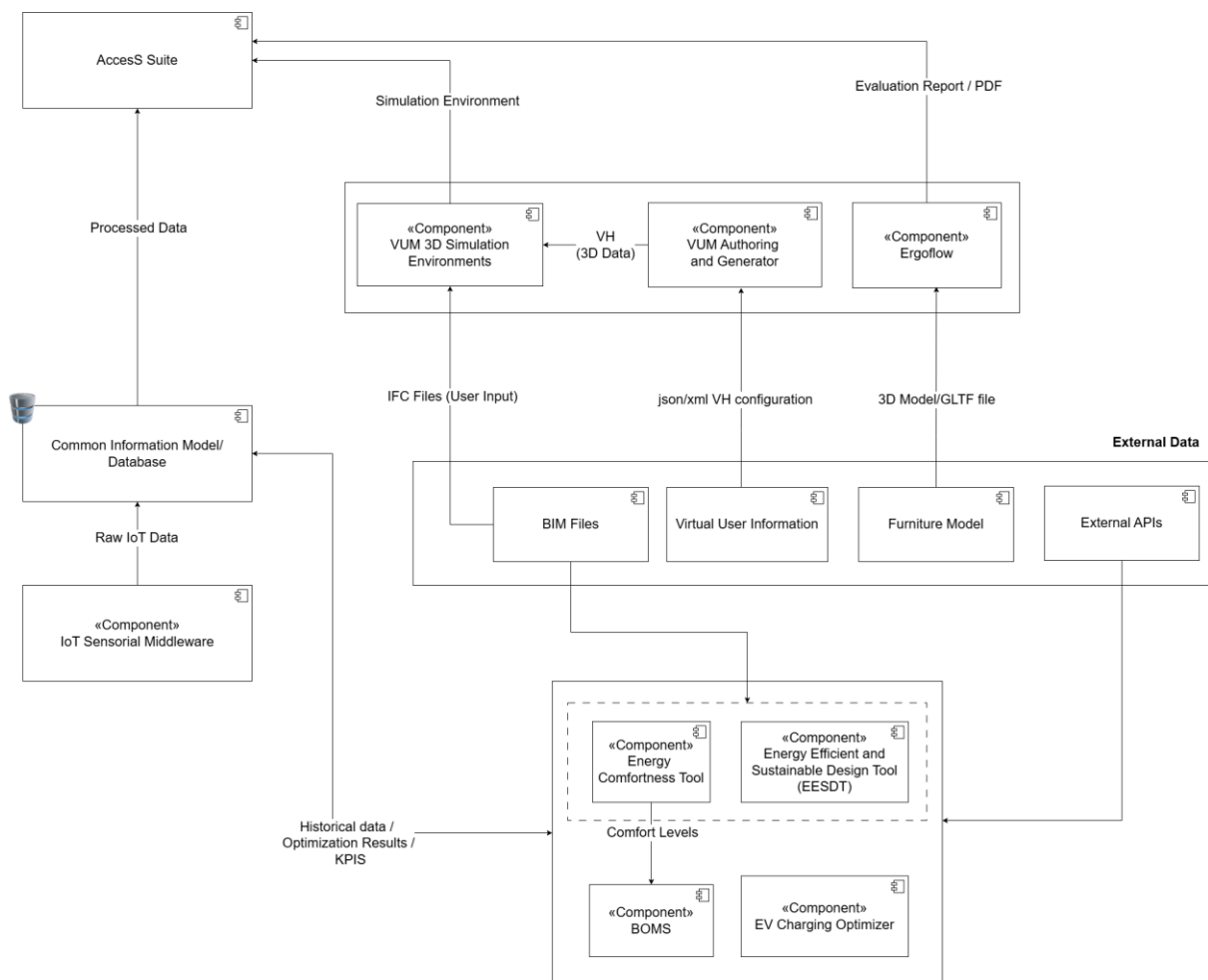


Figure 34. AccesS Information Flow Diagram

10 Technical Use Cases (Dynamic View)

The AccessS use cases were extracted during T1.3 meetings and architecture workshops as well as through bilateral communications between technical partners and pilot sites representatives within the activities of T1.2. The dependencies between the key architectural components and the data exchanged during the system's functions or procedures have been identified as part of this process. The logic behind these operations is presented through Sequence Diagrams highlighting the functionalities of each of the key architectural components and the execution flows within each use case. Besides these sequence diagrams, the requirements for each use case have been defined following the template introduced in Section 2, and are presented as well.

10.1 BS1: Assessment of accessibility for the built environment

10.1.1 UC1.1: Assessment of physical accessibility

Table 19. UC1.1 Description

Use Case #	UC1.1
Use Case Name	Assessment of physical accessibility
Intent	The tool enables the assessment of physical accessibility features according to accessibility guidelines.
Version/ Author	v1/ FORTH- FRC
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	This tool will allow involved actors to get an overview on what extend a building environment conforms with physical accessibility guidelines based on accessibility standards. Actors will be asked to provide data on aspects related to physical accessibility within a building. The tool will provide assessment reports based on specific use case scenarios. More specifically, the tool will include the following interactions: 1. The user creates a new project providing specific characteristics for the building environment. 2. The UI submits the building environment characteristics to the tool. 3. The tool saves the new project to the database. 4. The database returns the new project to the tool. 5. The tool requests from the database all the related assignments grouped by the selected categories. 6. The database returns results to the tool. 7. The tool returns results to the UI.

	8. The UI displays the list of the available assessment categories. 9. The user selects a category related to physical accessibility. 10. The UI filters the assignments that belong to the specific category. 11. The UI displays all the assignments related to physical accessibility. 12. For each assignment form the user provides the data required. 13. The UI submits the assignment to the tool. 14. The tool executes the assessment process. 15. The tool returns the accessibility assessment findings along with scores and comments to the UI. 16. The UI displays the accessibility assessment findings along with scores and comments to the user. 17. The user saves the assessment findings to the project. 18. The UI requests from the tool to save the project. 19. The tool saves the assessment findings of the project to the database. 20. The database returns the updated project to the tool. 21. The tool returns the response to the UI. 22. The UI displays the response.
Pre-conditions	Information regarding specific characteristics of the building is needed beforehand.
Trigger	The user needs to receive an assessment report regarding physical accessibility in the building environment.
Goal (Successful End Condition)	The user receives an assessment report regarding physical accessibility.
Post Conditions	Assessment report on physical accessibility will be available accompanied with comments for improvement.
Related Use Cases	UC1.4

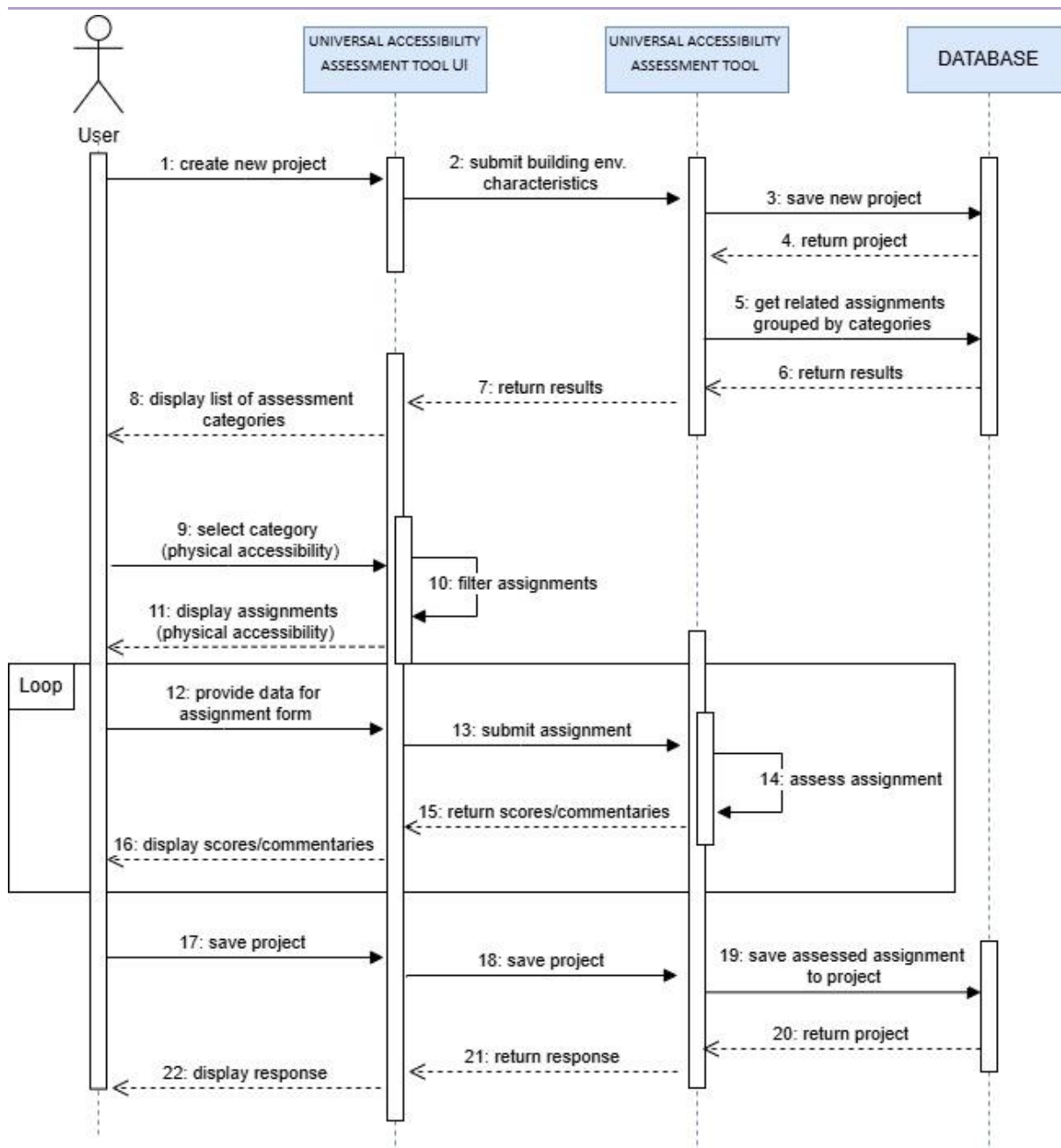


Figure 35. UC1.1 Sequence Diagram

10.1.2 UC1.2: Assessment of usability, safety and comfort

Table 20. UC1.2 Description

Use Case #	UC1.2
Use Case Name	Assessment of usability, safety and comfort
Intent	The tool enables the assessment of usability, safety and comfort features within a building environment.

Version/ Author	v1/ FORTH- FRC
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	This tool will allow involved actors to get an overview on what extend a building environment conforms with usability, safety and comfort. Actors will be asked to provide data on related aspects within a building. The tool will provide assessment reports based on specific use case scenarios. More specifically, the tool will include the following interactions: 1. The user creates a new project providing specific characteristics for the building environment. 2. The UI submits the building environment characteristics to the tool. 3. The tool saves the new project to the database. 4. The database returns the new project to the tool. 5. The tool requests from the database all the related assignments grouped by the selected categories. 6. The database returns results to the tool. 7. The tool returns results to the UI. 8. The UI displays the list of the available assessment categories. 9. The user selects a category related to usability, safety and comfort. 10. The UI filters the assignments that belong to the specific category. 11. The UI displays all the assignments related to usability, safety and comfort. 12. For each assignment form the user provides the data required. 13. The UI submits the assignment to the tool. 14. The tool executes the assessment process. 15. The tool returns the accessibility assessment findings along with scores and comments to the UI. 16. The UI displays the accessibility assessment findings along with scores and comments to the user. 17. The user saves the assessment findings to the project. 18. The UI requests from the tool to save the project. 19. The tool saves the assessment reports of the project to the database. 20. The database returns the updated project to the tool. 21. The tool returns the response to the UI. 22. The UI displays the response.
Pre-conditions	Information regarding specific characteristics of the building is needed beforehand.
Trigger	The user needs to receive an assessment report regarding usability, safety and comfort in the building environment.

Goal (Successful End Condition)	The user receives an assessment report regarding usability, safety and comfort.
Post Conditions	Assessment report on usability, safety and comfort will be available accompanied with comments for improvement.
Related Use Cases	UC1.4

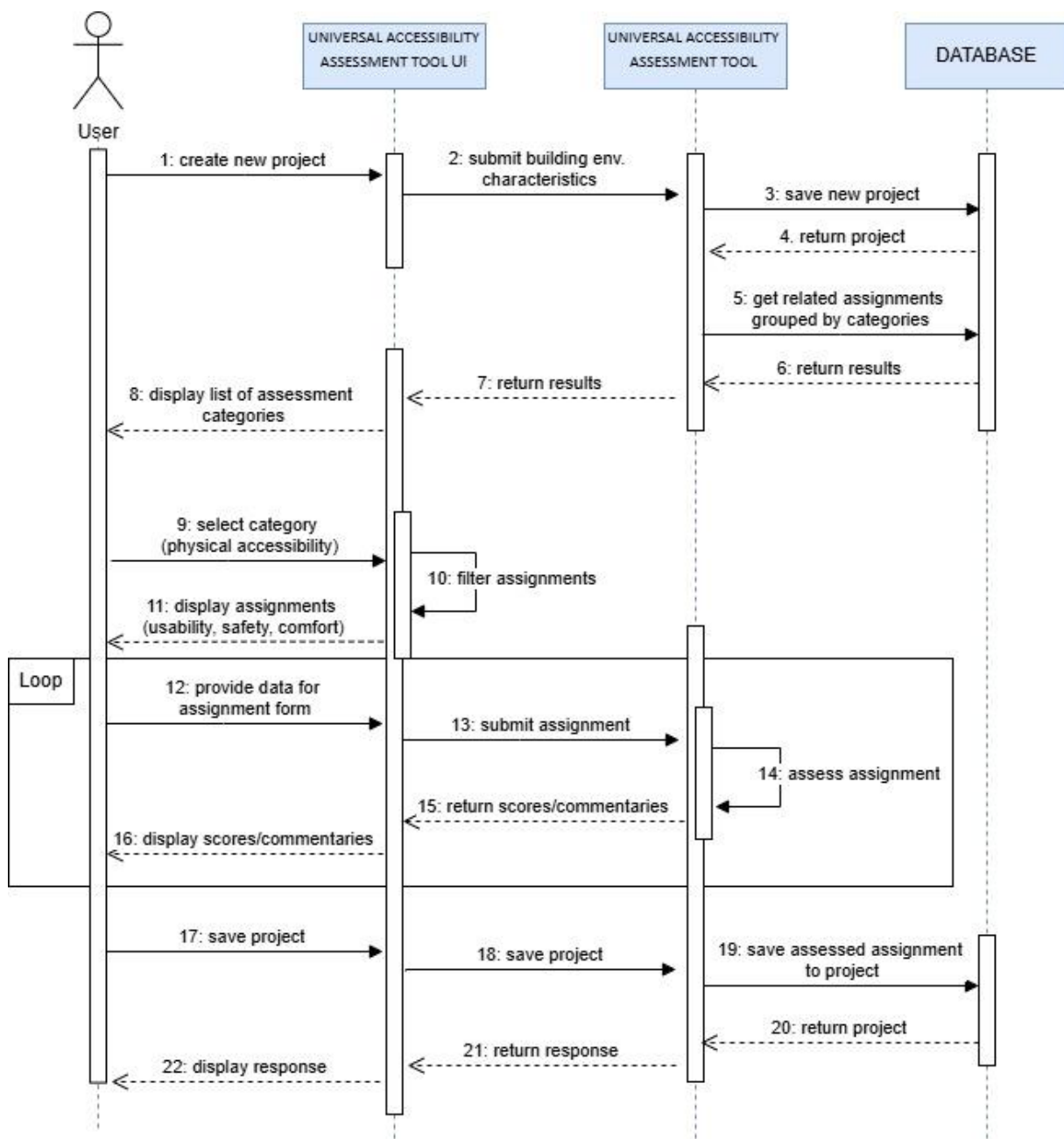


Figure 36. UC1.2 Sequence Diagram

10.1.3 UC1.3: Assessment of social inclusion

Table 21. UC1.3Description

Use Case #	UC1.3
Use Case Name	Assessment of social inclusion
Intent	The tool enables the assessment of social inclusion features according to accessibility guidelines.
Version/ Author	v1/ FORTH- FRC
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	This tool will allow involved actors to get an overview on what extend a building environment conforms with social inclusion guidelines. Actors will be asked to provide data on aspects related to social inclusion within a building. The tool will provide assessment reports based on specific use case scenarios. More specifically, the tool will include the following interactions: 1. The user creates a new project providing specific characteristics for the building environment. 2. The UI submits the building environment characteristics to the tool. 3. The tool saves the new project to the database. 4. The database returns the new project to the tool. 5. The tool requests from the database all the related assignments grouped by the selected categories. 6. The database returns results to the tool. 7. The tool returns results to the UI. 8. The UI displays the list of the available assessment categories. 9. The user selects a category related to social inclusion. 10. The UI filters the assignments that belong to the specific category. 11. The UI displays all the assignments related to social inclusion. 12. For each assignment form the user provides the data required. 13. The UI submits the assignment to the tool. 14. The tool executes the assessment process. 15. The tool returns the accessibility assessment findings along with scores and comments to the UI. 16. The UI displays the accessibility assessment findings along with scores and comments to the user. 17. The user saves the assessment findings to the project. 18. The UI requests from the tool to save the project.

	19. The tool saves the assessment reports of the project to the database. 20. The database returns the updated project to the tool. 21. The tool returns the response to the UI. 22. The UI displays the response.
Pre-conditions	Information regarding specific characteristics of the building is needed beforehand.
Trigger	The user needs to receive an assessment report regarding social inclusion in the building environment.
Goal (Successful End Condition)	The user receives an assessment report regarding social inclusion.
Post Conditions	Assessment report on social inclusion will be available accompanied with comments for improvement.
Related Use Cases	UC1.4

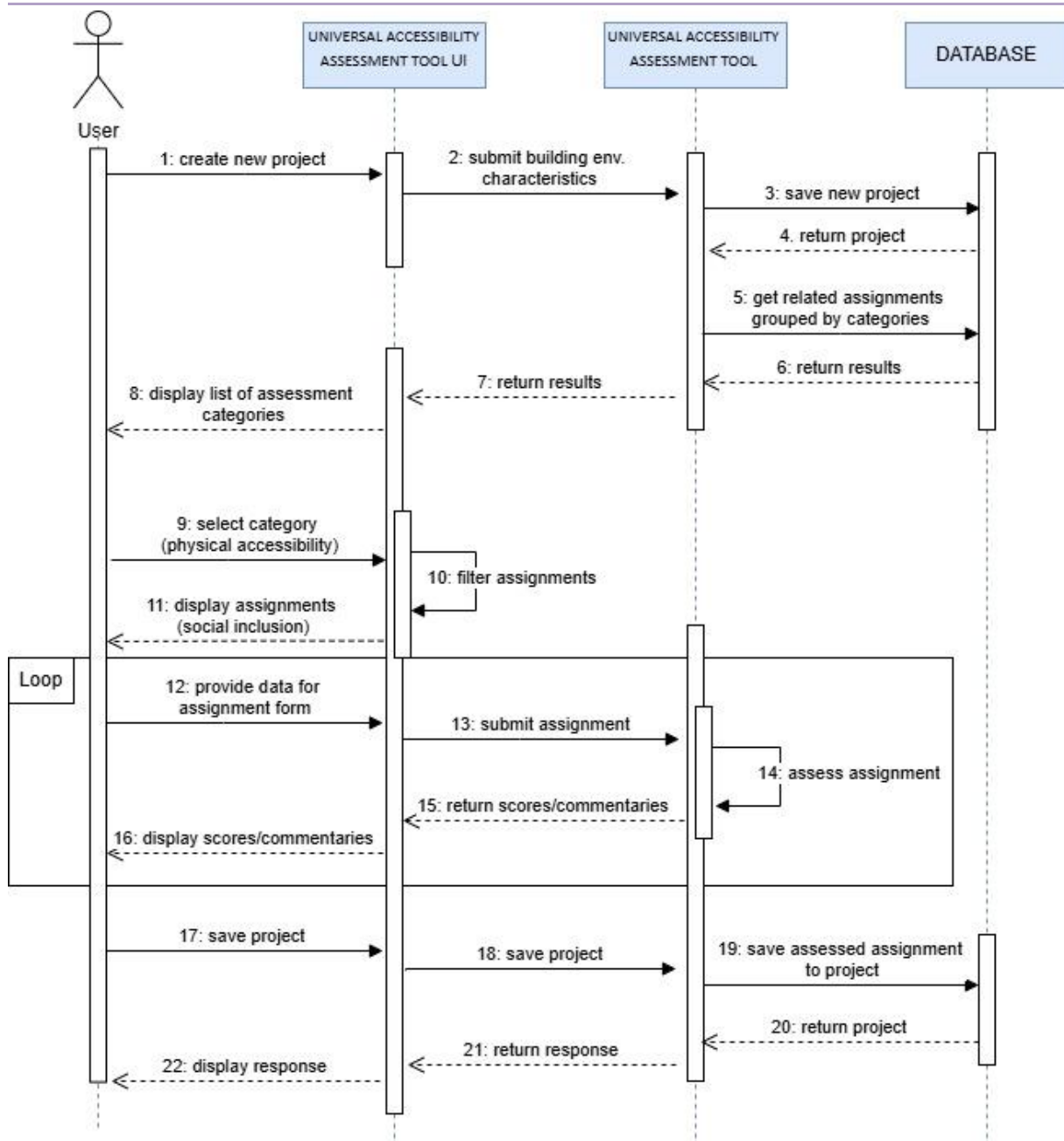


Figure 37. UC1.3 Sequence Diagram

10.1.4 UC1.4: Issue a building certification report according to AccessS Accessibility Assessment Scheme

Table 22. UC1.4 Description

Use Case #	UC1.4
Use Case Name	Issue a building certification report according to AccessS Accessibility Assessment Scheme

Intent	Enable the assessment of accessibility features according to accessibility guidelines.
Version/ Author	v1/ FORTH- FRC
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	This tool will provide an assessment certification report detailing the results of the accessibility evaluation, including areas of non-compliance. In detail, it will provide a clear report based on the accessibility evaluation results for a specific building environment according to the AccessS Accessibility Scheme. It will include the following interactions: 1. The user selects a project. 2. The UI requests from the tool the assessed assignments related to the specific project. 3. The tool gets the assessed assignments from the database. 4. The database returns the assessed assignments to the tool. 5. The tool returns the results to the UI. 6. The UI displays the list of assessed assignments to the user. 7. The user requests an assessment report for the specific project. 8. The UI requests from the tool to issue the assessment report. 9. The tool generates the certification report, as long as the minimum required assignments are met. 10. The tool returns the certification report to the UI. 11. The UI displays the certification report to the user.
Pre-conditions	The user should successfully have completed the minimum required assignments for accessibility evaluation.
Trigger	The user needs to receive a certification report detailing the results of the accessibility evaluation, including areas of non-compliance.
Goal (Successful End Condition)	The user receives a certification report summarizing the accessibility assessment findings.
Post Conditions	The assessment certification report will be available for the user.
Related Use Cases	UC1.1, UC1.2, UC1.3

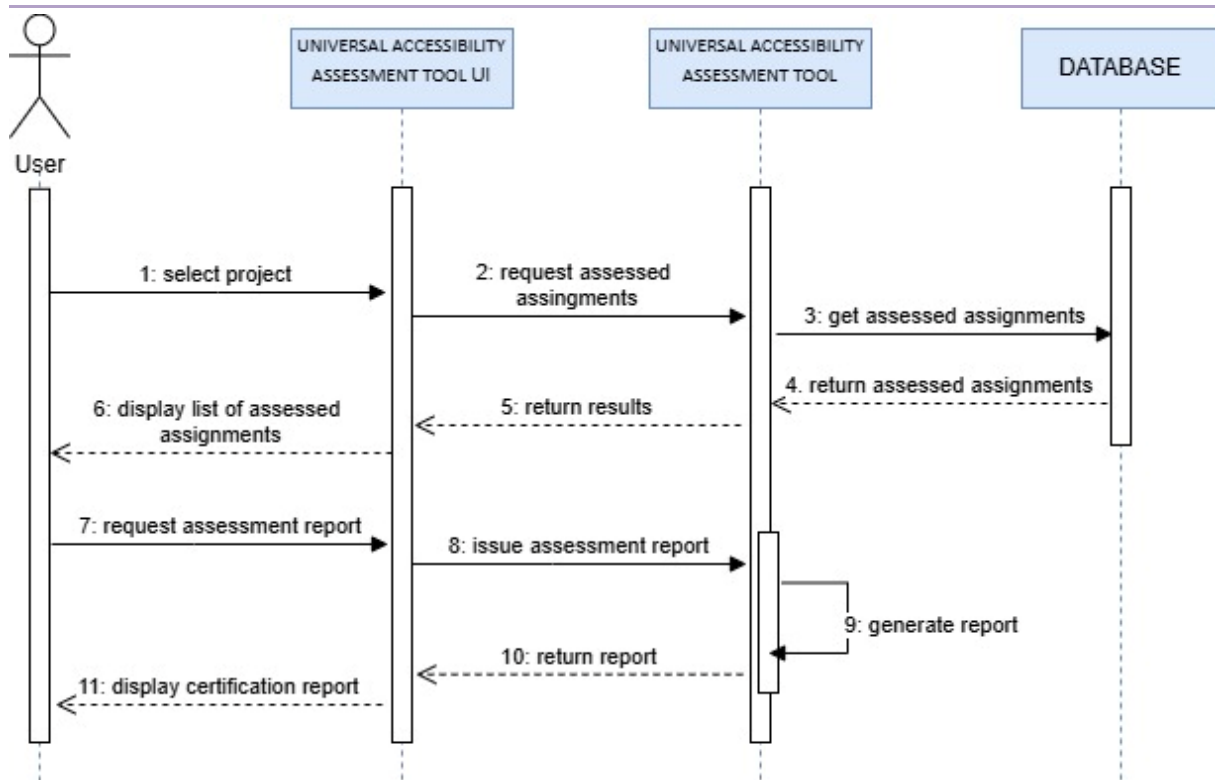


Figure 38. UC1.4 Sequence Diagram

10.2 BS2: Optimization of energy efficiency and user comfort

10.2.1 UC2.1: Assessment of baseline building energy performance

Table 23. UC2.1 Description

Use Case #	UC2.1
Use Case Name	Assessment of baseline building energy performance.
Intent	To evaluate the baseline apartment/ building's energy performance (current state) based on the provided BIM and energy monitoring data.
Version/ Author	v1/ QUE
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	1. The user logs in to the UI of the EESDT tool. 2. The UI requests access from the EESDT tool. 3. The EESDT returns the projects list to the user. 4. The user selects a project (which corresponds to a building). 5. The EESDT UI requests baseline from EESDT.

	6. This creates a request to evaluate the baseline (in terms of specific energy KPIs) of the building from the Baseline Scenario Generator. The IFC file has been uploaded by the user. This request sent to the Baseline Scenario Generator creates two IFCs (one for the building as-is – uploaded by the user – and one that corresponds to maximum enhancement scenario). 7. The IFCs are returned to EESDT. 8. EESDT requests transformation of IFC to IDF from the BEP Simulation Engine. 9. The BEP Simulation Engine performs this transformation. 10. The BEP Simulation Engine returns the IDF file to EESDT. 11. EESDT requests annual weather data from External Weather APIs. 12. External Weather APIs return annual weather data to EESDT. 13. EESDT performs weather data processing. 14. EESDT requests energy simulation from the BEP Simulation Engine. 15. The BEP Simulation Engine runs the energy simulation. 16. The BEP Simulation Engine returns the results to EESDT. 17. EESDT requests energy KPIs calculation from the BEP Simulation Engine. 18. The BEP Simulation Engine processes the output of the energy simulation. 19. The BEP Simulation Engine returns energy KPIs to EESDT. 20. EESDT returns baseline evaluation (IFCs, KPIs) to the EESDT UI. The EESDT UI displays the IFCs and the corresponding KPIs to the user.
Pre-conditions	• The end-user uploads the BIM file of the existing apartment / building. • The BIM file contains complete and correct information of the apartment / building.
Trigger	A request for baseline KPIs calculation.
Goal (Successful End Condition)	Specific KPIs will be presented to the end-user, showing the performance of the dwelling in its initial condition (prior to the renovation). Baseline assessment will be then compared with the performance of each renovation scenario that will be simulated by the AccesS tool in order to estimate the potential energy savings.
Post Conditions	Building Data are available for other processes and operations
Related Use Cases	UC 2.2, UC 2.3

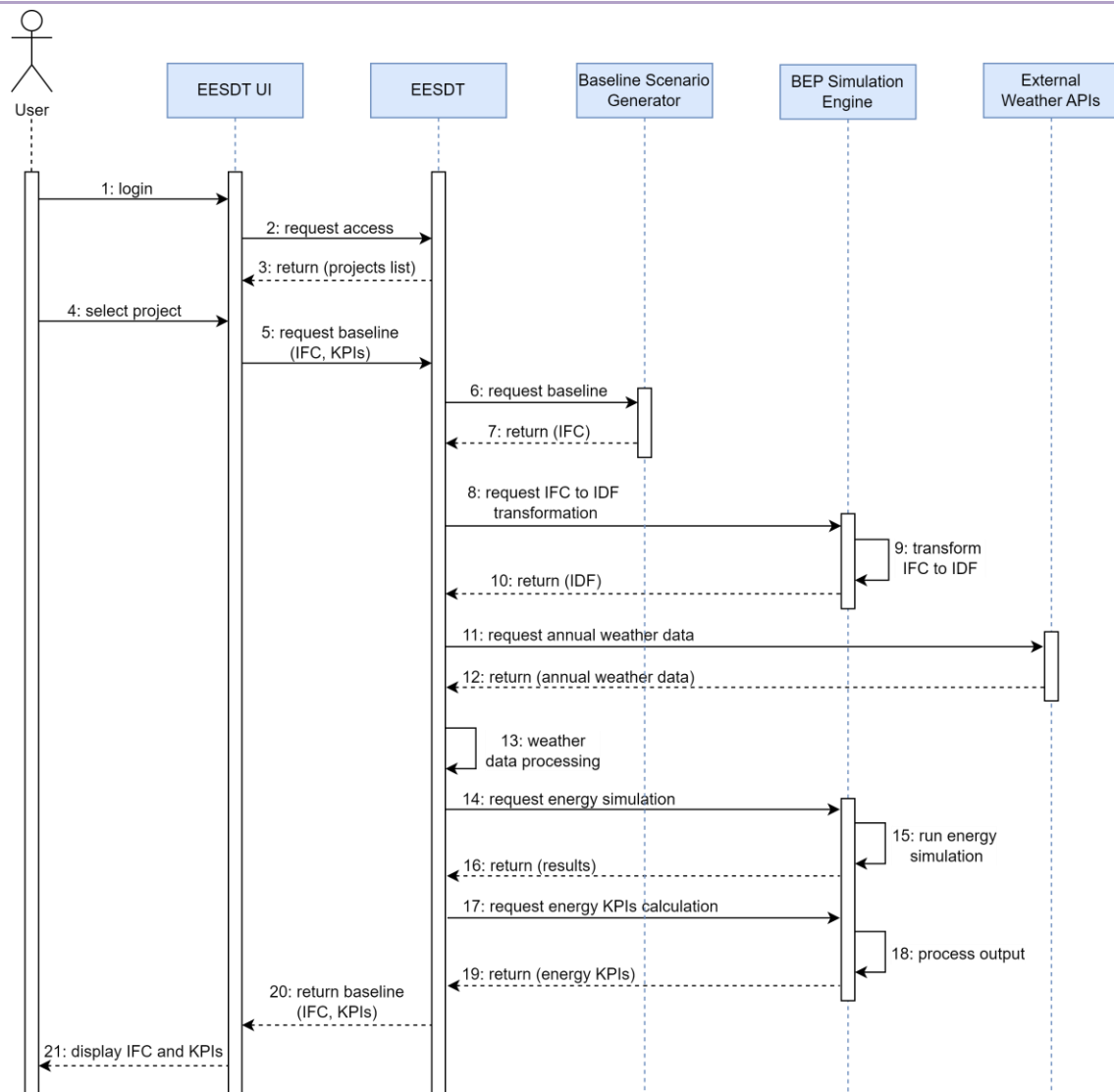


Figure 39. UC2.1 Sequence Diagram

10.2.2 UC2.2: Generation and evaluation of BIM-based renovation scenarios

Table 24. UC2.2 Description

Use Case #	UC2.2
Use Case Name	Generation and evaluation of BIM-based renovation scenarios.
Intent	The scope of this use case is to create renovation scenarios starting from the existing condition of an apartment / building (initial BIM file) and then evaluate the proposed scenarios based on energy and financial aspects.

Version/ Author	v1/ QUE
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	1. The user logs in to the UI of the EESDT tool. 2. The UI requests access from the EESDT tool. 3. The EESDT returns the projects list to the user. 4. The user selects a project. 5. The EESDT UI requests baseline from EESDT. 6. The EESDT returns the baseline (already evaluated in UC 2.1) to the EESDT UI. 7. The EESDT UI displays the IFCs and the corresponding KPIs to the user. 8. The user can select 'define renovation measures' tab on the EESDT UI. 9. The EESDT UI requests renovation measures from EESDT. 10. EESDT returns the list of renovation measures to the EESDT UI. 11. The user selects renovation measures. 12. The EESDT requests for scenario generation from the What-If Scenarios Generator. 13. The What-If Scenarios Generator generates scenarios. 14. The What-If Scenarios Generator send the generated IFCs to EESDT. • (loop: for each renovation scenario) 15. EESDT requests transformation of IFC to IDF from the BEP Simulation Engine. 16. The BEP Simulation Engine performs this transformation. 17. The BEP Simulation Engine returns the IDF file to EESDT. 18. EESDT requests energy simulation from the BEP Simulation Engine. 19. The BEP Simulation Engine runs the energy simulation. 20. The BEP Simulation Engine returns the results to EESDT. 21. EESDT requests energy KPIs calculation from the BEP Simulation Engine. 22. The BEP Simulation Engine processes the output of the energy simulation. 23. The BEP Simulation Engine returns energy KPIs to EESDT. • (loop: end) 24. EESDT requests optimization from the Renovation Scenarios Optimization Engine. 25. The Renovation Scenarios Optimization Engine performs the optimization. 26. The Renovation Scenarios Optimization Engine returns the optimization results (i.e., the most cost-effective renovation solutions). 27. The user can select 'renovation scenarios assessment' tab on the EESDT UI.

	28. The EESDT UI requests renovation measures information and associated KPIs from EESDT. 29. EESDT returns the requested information to the EESDT UI. The EESDT UI presents this information to the user.
Pre-conditions	• The end-user uploads the BIM file of the existing apartment / building. • The BIM file contains complete and correct information of the apartment / building.
Trigger	End-user requests evaluation of renovation scenarios.
Goal (Successful End Condition)	Selected key information, such as energy savings and cost of renovation scenarios, will be illustrated to the end-user in a user-friendly way so that concerned actors can decide on optimal solution.
Post Conditions	Building Data are available for other processes and operations
Related Use Cases	UC 2.1, UC 2.3

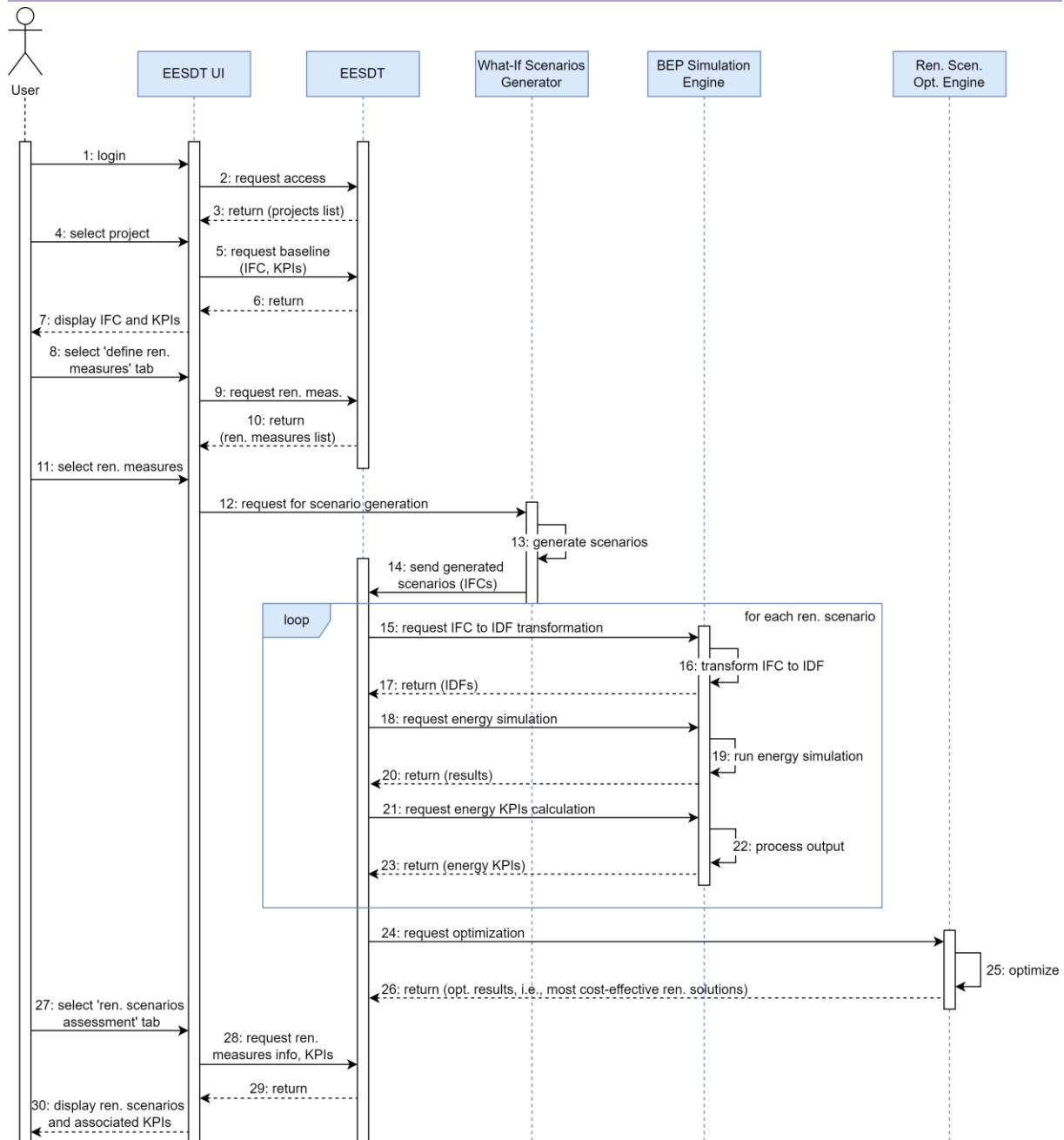


Figure 40. UC2.2 Sequence Diagram

10.2.3 UC2.3: Visualization of baseline and renovation scenarios KPIs to support decision making

Table 25. UC2.3 Description

Use Case #	UC2.3
Use Case Name	Visualization of baseline and renovation scenarios KPIs to support decision making.

Intent	Present potential renovation scenarios as a tangible solution for supporting decision making on future renovation activities.
Version/ Author	v1/ QUE
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	1. The user logs in to the UI of the EESDT tool. 2. The UI requests access from the EESDT tool. 3. The EESDT returns the projects list to the user. 4. The user selects a project. 5. The EESDT UI requests baseline from EESDT. 6. The EESDT returns the baseline (already evaluated in UC 2.1) to the EESDT UI. 7. The EESDT UI displays the IFCs and the corresponding KPIs to the user. 8. The user can select 'renovation scenarios assessment' tab on the EESDT UI. 9. The EESDT UI requests renovation measures information, associated KPIs, and optimization results. 10. EESDT returns this information to the EESDT UI. The EESDT UI shows this information to the user.
Pre-conditions	• The end-user uploads the BIM file of the existing apartment / building. • The BIM file contains complete and correct information of the apartment / building.
Trigger	End-user requests visualization of baseline and renovation scenarios KPIs.
Goal (Successful End Condition)	The end-users will select the renovation scenario that better suits their needs.
Post Conditions	Material/ component/ energy conservation measures database is populated. Baseline and renovation scenarios KPIs have been calculated and available for other processes.
Related Use Cases	UC 2.1, UC 2.2

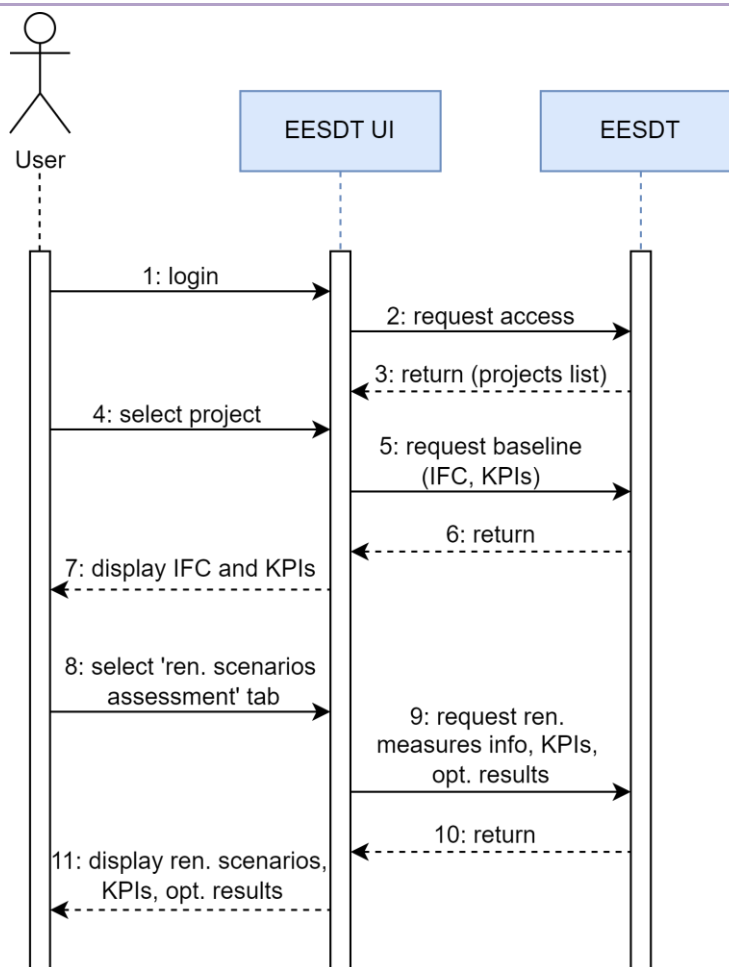


Figure 41. UC2.3 Sequence Diagram

10.2.4 UC2.4: Simulate occupant comfort levels and its impact on the building's energy consumption

Table 26. UC2.4 Description

Use Case #	UC2.4
Use Case Name	Simulate occupant comfort levels and its impact on the building's energy consumption
Intent	Simulate the comfort levels and their energy footprint of occupants of a given profile in a specific space.
Version/ Author	v1/ UNIS
Actors Involved	Main actors: Architects, Interior Designers, Civil Engineers Other: Building Managers, Renovation/ Constructing Companies, Researchers / Academics, Tenants/Owners, End-Users.

Brief Description	1. The user logs in the Access Suite Platform using their credentials (username/password). 2. The Access Suite Platform authenticates and authorizes the user through User Authentication 3. Upon successful authentication, access is granted to the ECD 4. The user selects the desired ECD simulation 5. The Access Suite Platform redirects the user to the selected Dashboard, providing access to the related features. 6. The simulation ECD retrieves and displays a list of available spaces for each Pilot Building for which the simulation can be performed 7. The user configures the simulation space scenarios by performing the following actions: a) selects the space of interest (drop-down UI element), b) selects an occupant profile (drop-down UI element) and c) inputs the simulation parameters (e.g. optional fixed weather parameters such as outdoor temperature and humidity, timeline for simulations (including occupancy), outdoor noise level) through the respective UI fields 8. The user selects the “Submit” button in order to request a simulation scenario from the ECE 9. ECD sends the user configuration to ECE 10. ECE requests the corresponding IFC file for the selected space from the corresponding data lake of IoT Information Layer 11. ECE retrieves the related IFC Files (based on the selected space) 12. ECE converts it to a building energy simulation proper format (IDF) 13. ECE isolates the space of interest (extracts the geometry and structural properties of the space) 14. ECE requests weather data from an external weather API (if fixed weather configuration is not set by the user) 15. If a request was sent, the external weather API returns the weather data 16. ECE runs comfort (thermal, acoustic, visual, IAQ) and energy simulations with related trained ML and conventional models 17. ECE returns the simulation results to ECD 18. ECD returns and displays the simulation results to the user
Pre-conditions	BIM in IFC format files • Space assigned in BIM • Occupant profiles containing necessary variables (e.g., occupant age, metabolic rate, clothing) • Trained Machine-Learning models for each comfort feature • Availability of external weather API • The end-user uploads the BIM file of the existing apartment / building. • The BIM file contains complete and correct information

	- The end-user uploads the occupants' profiles with necessary info - The external weather API is available - The ML & models are trained per each comfort feature/level
Trigger	Request of simulating energy comfortness for a scenario dictated by the selection of a space and an occupant profile.
Goal (Successful End Condition)	Visualize the expected building behaviour in terms of comfort and related energy efficiency to optimize its design.
Post Conditions	Building Data are available for other processes and operations The simulation results have been stored and available for other processes
Related Use Cases	UC2.5, UC5.1, UC5.2, UC5.3

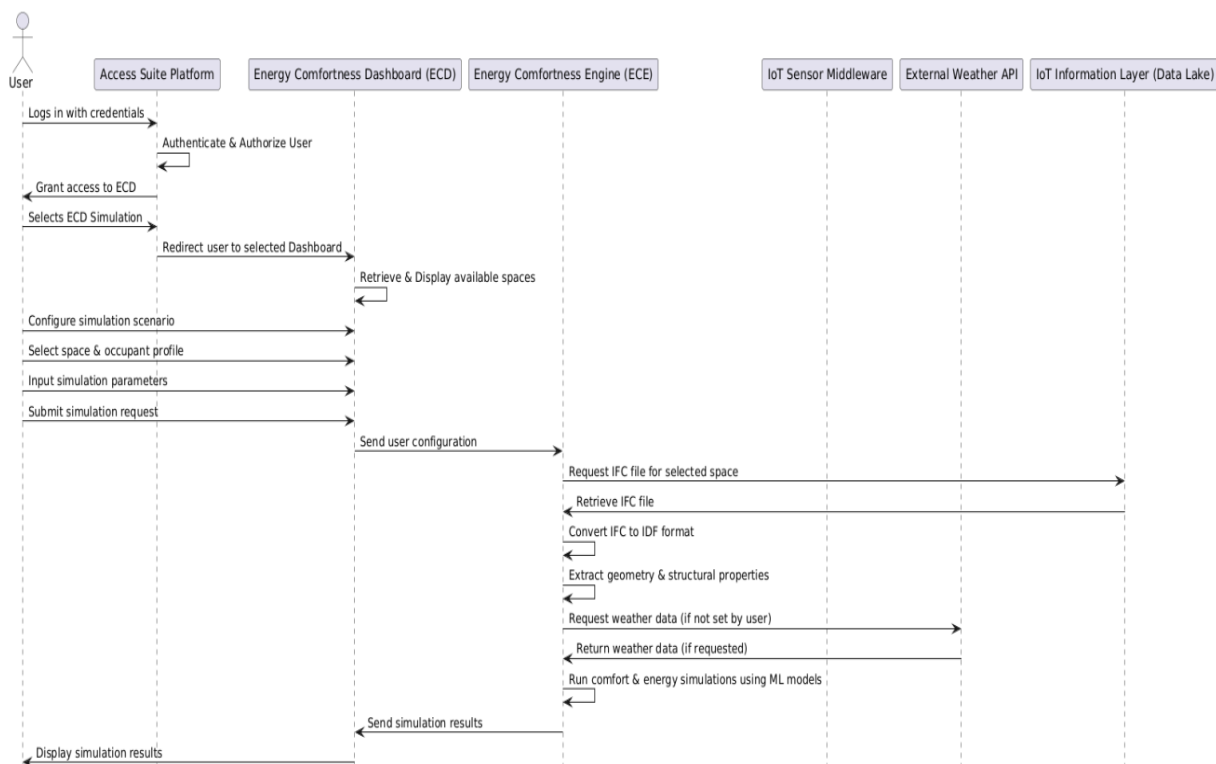


Figure 42. Sequence diagram for UC2.4, displaying the sequence of events involved in simulating.

10.2.5 UC2.5: Monitor occupant comfort levels and its impact on the building's energy consumption

Table 27. UC2.5 Description

Use Case #	UC2.5
Use Case Name	Monitor occupant comfort levels and its impact on the building's energy consumption
Intent	Monitoring building comfort and energy efficiency levels by real-time data
Version/ Author	v1/ UNIS
Actors Involved	Main actors: Architects, Interior Designers, Civil Engineers Other: Building Managers, Renovation/ Constructing Companies, Researchers / Academics, Tenants/Owners, End-Users
Brief Description	1. The user logs in to the AccesS Suite Platform using their credentials (username/password). 2. The AccesS Suite Platform authenticates and authorizes the user using User Authentication 3. Upon successful authentication, access is granted to the ECD 4. The user selects the desired ECD monitoring 5. The AccesS Suite Platform redirects the user to the selected Dashboard, providing access to the related features. 6. The monitoring ECD UI retrieves and displays a list of available spaces for each Pilot Building, where monitoring can be performed. 7. The user configures the monitoring Building space by performing the following actions: 8. a) Selects a space of interest from a drop-down UI element. 9. b) Selects an occupant profile from a drop-down UI element. 10. The user selects the "Submit" button to request a monitoring for specific space from the ECE. 11. ECD sends the user configuration to ECE 12. ECE requests the corresponding IFC file for the selected space from the corresponding data lake of IoT Information Layer 13. ECE retrieves the related IFC Files (based on the selected space) 14. ECE converts the IFC file to IDF format 15. ECE extracts the geometry and structural properties of the space. 16. ECE requests consolidation/aggregated sensor data for the space (e.g., time interval per hour) from IoT Sensor Middleware 17. ECE retrieved consolidated/aggregated sensor data from IoT Sensor Middleware 18. ECE retrieves weather data from an external weather API. 19. ECE evaluates comfort levels and energy performance using trained Machine Learning models. 20. ECE sends the evaluation results to ECD. 21. ECD displays comfort and energy monitoring data to the user. 22. The process repeats at intervals based on the sensor sampling rate.

Pre-conditions	- BIM in IFC format files - Consolidation/Aggregation data from smart sensors and IoT devices
Trigger	Request of visualizing real-time estimates of comfort levels and related energy efficiency.
Goal (Successful End Condition)	Visualize the current building behavior in terms of comfort and related energy efficiency for monitoring purposes.
Post Conditions	Building Data are available for other processes and operations
Related Use Cases	UC2.5, UC5.1, UC5.2, UC5.3
Use Case #	UC2.5
Use Case Name	Monitor occupant comfort levels and its impact on the building's energy consumption
Intent	Monitoring building comfort and energy efficiency levels by real-time data
Version/ Author	v1/ UNIS
Last Update	
Actors Involved	Main actors: Architects, Interior Designers, Civil Engineers Other: Building Managers, Renovation/ Constructing Companies, Researchers / Academics, Tenants/Owners, End-Users
Brief Description	The building manager / designer requests visualization and analytics of the as-is situation for the building. The Energy Comfortness Tools requests the relevant prepared data from its ML database (raw data from the AccesS data services will have first been acquired and processed with the Tool's ETL process) and feeds them to the loaded models to infer comfort levels and energy efficiency. Then, the Tool visualizes results in the BIM visualization and data analytics dashboard.
Pre-conditions	- BIM in IFC format files - Real-time data from smart sensors and IoT devices
Trigger	Request of visualizing real-time estimates of comfort levels and related energy efficiency.
Goal (Successful End Condition)	Visualize the current building behavior in terms of comfort and related energy efficiency for monitoring purposes.

Post Conditions	Building Data are available for other processes and operations
Related Use Cases	UC2.5, UC5.1, UC5.2, UC5.3

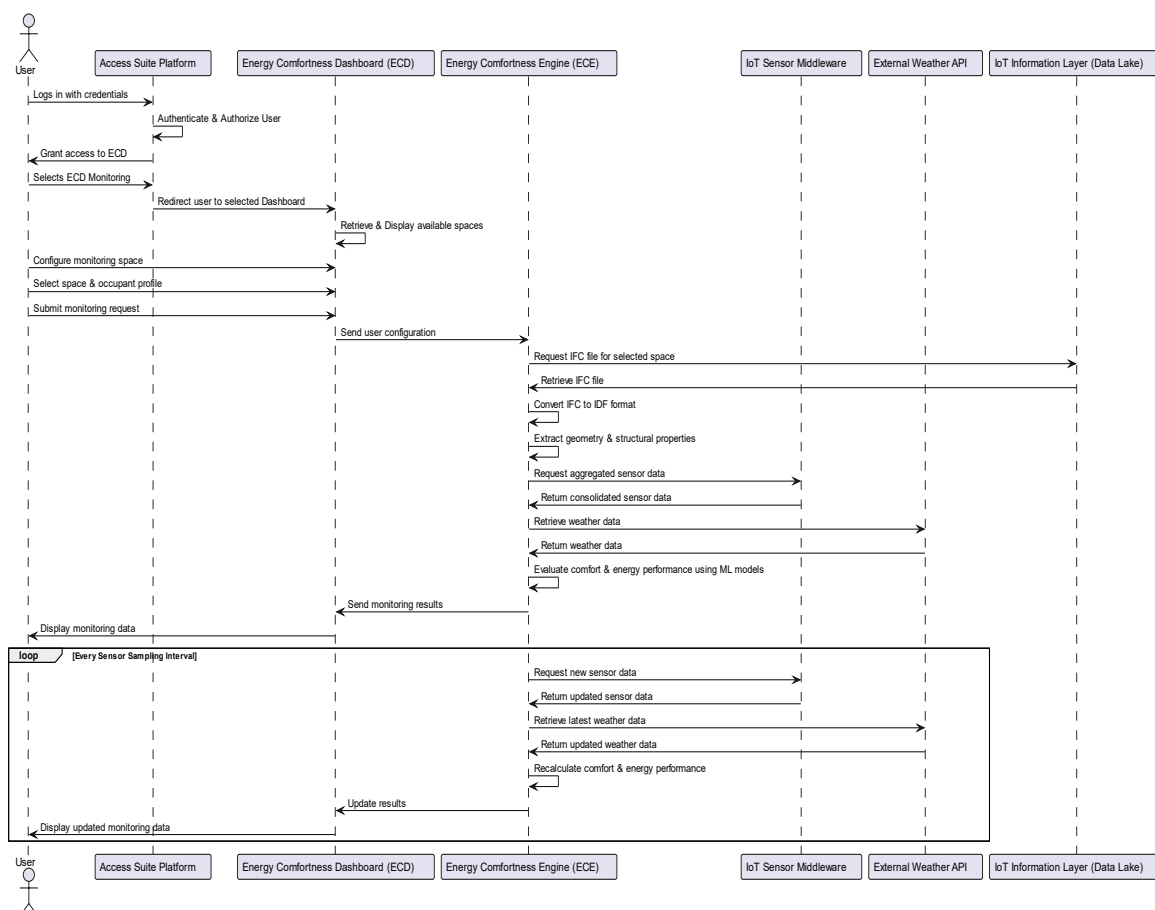


Figure 43. Sequence diagram for UC2.5, displaying the sequence of events involved in monitoring energy comfortness.

10.3 BS3: Design of ergonomically adapted products

10.3.1 UC3.1: Evaluate the ergonomics of 3D models of furniture items

Table 28. UC3.1 Description

Use Case #	UC3.1
Use Case Name	Evaluate the ergonomics of 3D models of furniture items.

Intent	Provide simulation and testing functionalities to assess the ergonomic compliance of furniture items, ensuring that they meet the accessibility and comfort needs of senior citizens and people with functional diversity.
Version/ Author	v1/ CETEM
Actors Involved	Main actors: product designers, architects, interior designers, manufacturers Other: Public bodies, researchers, building users
Brief Description	Once the product designer or architect accesses the user interface of the ErgoFlow tool, they are asked for the basic data of the new design. The user then enters data such as user typology, expected use, type of furniture, etc. and uploads the 3D model of the item. The UI sends the design information and the ErgoFlow tool asks the ergonomics database for the list of evaluation parameters based on the inputted data. Once the database returns the list of parameters based on the query, ErgoFlow asks the question based on one parameter (loop: for each parameter). The UI displays the query to the user, who must then answer it, after which the UI returns the parameter value to ErgoFlow. The tool thus returns the result of the processed parameter, and the UI lists it (loop: end). ErgoFlow then sends a report of the evaluation of the design in terms of ergonomics, accessibility, comfort, applicable EU safety standards, etc., and the UI displays the result of the evaluation, providing a downloadable report that offers, if necessary, a series of recommendations to improve the furniture piece and make it more ergonomic.
Pre-conditions	3D model of product
Trigger	The need to evaluate the ergonomics of a piece of furniture through a 3D design.
Goal (Successful End Condition)	Receiving a report that enables the designer to make improvements and adjustments to meet accessibility and comfort standards, ensuring adherence to ergonomic guidelines and other usability and accessibility criteria
Post Conditions	Product Data are available for other processes and operations
Related Use Cases	UC3.2

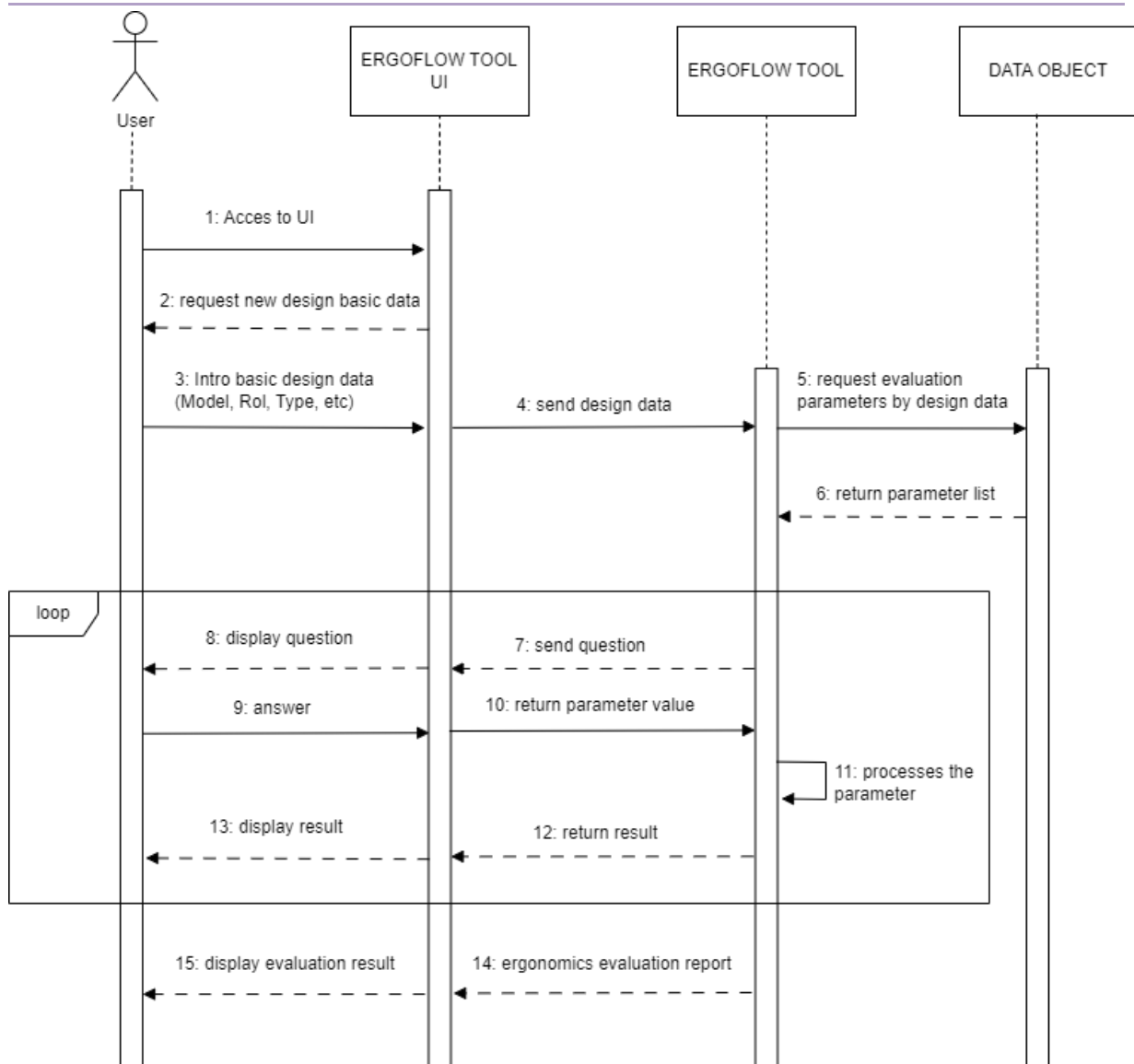


Figure 44. Sequence diagram of UC3.1

10.3.2 UC3.2: Visualization of ergonomically designed furniture items

Table 29. UC3.2 Description

Use Case #	UC3.2
Use Case Name	Visualization of ergonomically designed furniture items.
Intent	To access a collection of ergonomically designed furniture items that have been evaluated according to ergonomic principles and usability standards, with the possibility to be able to download these items and incorporate them into BIM scenarios and simulations.
Version/ Author	v1/ CETEM

Actors Involved	Main actors: product designers, architects, interior designers, furniture manufacturers. Other: Public bodies, students, researchers, building users.
Brief Description	An architect or product designer accesses the ErgoFlow library and selects a specific item from the catalogue of ergonomic products. The ErgoFlow library supports both uploading and downloading 3D models of furniture based on the project's use cases and categories (e.g., chairs, tables).
Pre-conditions	-
Trigger	To access the design characteristics of ergonomically complied products.
Goal (Successful End Condition)	To efficiently access, upload, and download 3D models of furniture from the ErgoFlow library, facilitating the selection of items tailored to specific project use cases and categories for seamless design integration.
Post Conditions	Product Data are available for other processes and operations
Related Use Cases	UC3.1
Use Case #	UC3.2
Use Case Name	Visualisation of ergonomics results of products.
Intent	To access ergonomically assessed products and allow the design of items complied with ergonomic principles and usability standards.
Version/ Author	v1/ CETEM
Last Update	
Actors Involved	Main actors: product designers, architects, interior designers, manufacturers Other: Public bodies, researchers, building users
Brief Description	A designer, architect, accesses the AccesS Suite and the Ergoflow tool and requests from the Catalogue of ergonomic products a specific item. Ergoflow subcomponent visualizes the 3D Model of the particular product and delivers a report of its properties to allow its re-creation. The report is supported with thye evaluation results from its ergonomics assessment.
Pre-conditions	-

Trigger	To access the design characteristics of ergonomically complied products.
Goal (Successful End Condition)	Obtaining a report from which the designer can manufacture the specific item.
Post Conditions	Product Data are available for other processes and operations
Related Use Cases	UC3.1

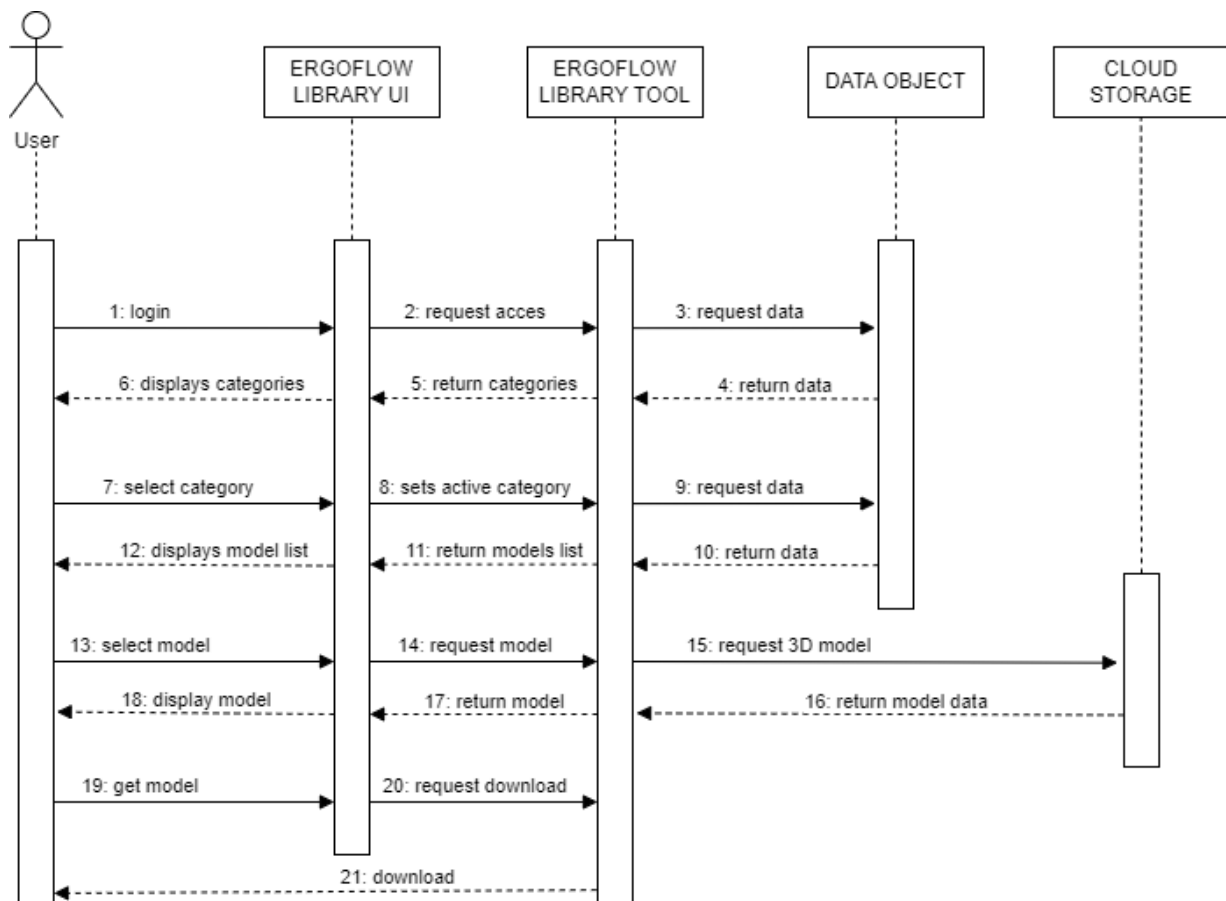


Figure 45. Sequence Diagram

10.4 BS4 Realistic human representation and simulation of user experience

This scenario will allow simulating user experience under different use cases and facilitate understanding of user needs under specific contexts. It will properly represent human features and their interaction under different scenarios to promote accessibility and inclusion while supporting the demonstration of design issues that should be considered to improve the capacity of delivering solutions designed for all.

To fully cover this scenario the following technical use cases have been identified:

- UC4.1- Digital authoring of Virtual User Models (VUMs)

- UC4.2- VUM-based Virtual Human authoring
- UC4.3- 3D Simulation for Wheelchair building accessibility
- UC4.4- 3D Simulation for building accessibility for the elderly
- UC4.5- 3D Simulation for building accessibility for visually impaired people
- UC4.6- 3D Simulation for building accessibility for auditory impaired people

10.4.1 UC4.1: Digital authoring of Virtual User Models (VUMs)

Table 30. UC4.1 Description

Use Case #	UC4.1
Use Case Name	Digital authoring of Virtual User Models (VUMs)
Intent	To represent aging individuals and people with disabilities in the form of Virtual User Models
Version/ Author	v1/ FORTH
Actors Involved	Main Actor: Building Industry, Professional consultants (e.g., architectural, engineering and financial), Tool developers, Building Material and Product Industries Other: Researchers/ Academia, Environmental/social campaigning organisations, Organisations representing people with disabilities, Potential users/clients for future projects, Public Bodies, EU legislative instruments, Standardization organizations
Brief Description	The editor offers intuitive user interfaces for configuring user model parameters in line with the VUM specification (the semantic representation of anthropometric and other parameters that describe aging individuals and people with disabilities). Specifically, the Digital Authoring Tool of VUMs will include the following interactions: 1. The user creates a new VUM based on specific properties. 2. The VUMs generator UI submits the VUM properties to the VUMs generator. 3. The VUMs generator stores semantic data to the VUMs semantic database. 4. The VUMs semantic database returns the VUM to the VUMs generator. 5. The VUMs generator returns the VUM to the VUMs generator UI. 6. The VUMs generator UI requests types of impairments from the VUMs generator. 7. The VUMs generator requests all the predefined impairment types from the VUMs semantic database. 8. The VUMs semantic database returns presets of impairments to the VUMs generator.

	9. The VUMs generator returns the presets of impairments to the VUMs generator UI. 10. The VUMs generator UI displays the presets of impairments to the user. 11. The user selects one or more types of impairments to be applied to a specific VUM (e.g. Osteoarthritis). 12. The VUMs generator UI applies the selected impairments to the VUMs generator. 13. The VUMs generator posts an update of the VUM to the VUMs semantic database. 14. The VUMs semantic database returns the updated VUM to the VUMs generator. 15. The VUMs generator returns the updated VUM to the VUMs generator UI. 16. The user configures the selected impairments in a high-level approach (e.g. Affected area: Hands). 17. The VUMs generator UI requests from the VUMs generator to apply the updates to the VUM. 18. The VUMs generator posts an update with the configured impairments to the VUMs semantic database. 19. The VUMs semantic database returns the updated VUM to the VUMs generator. 20. The VUMs generator returns the updated VUM to the VUMs generator UI. 21. The user configures the selected impairments in a low-level approach (e.g. grip strength, wrist extension, etc.). 22. The VUMs generator UI requests from the VUMs generator to apply the updates to the VUM. 23. The VUMs generator posts an update with the configured impairments to the VUMs semantic database. 24. The VUMs semantic database returns the updated VUM to the VUMs generator. 25. The VUMs generator returns the updated VUM to the VUMs generator UI. 26. The VUMs generator UI displays the updated VUM.
Pre-conditions	User specifications and characteristics
Trigger	User's request for authoring a specific virtual user model
Goal (Successful End Condition)	To produce Virtual User Models representing individuals with specific characteristics such as elderly people or people with disabilities.
Post Conditions	Virtual User Models are available for Virtual Humans authoring
Related Use Cases	UC4.2, UC.4.3, UC4.5, UC4.6

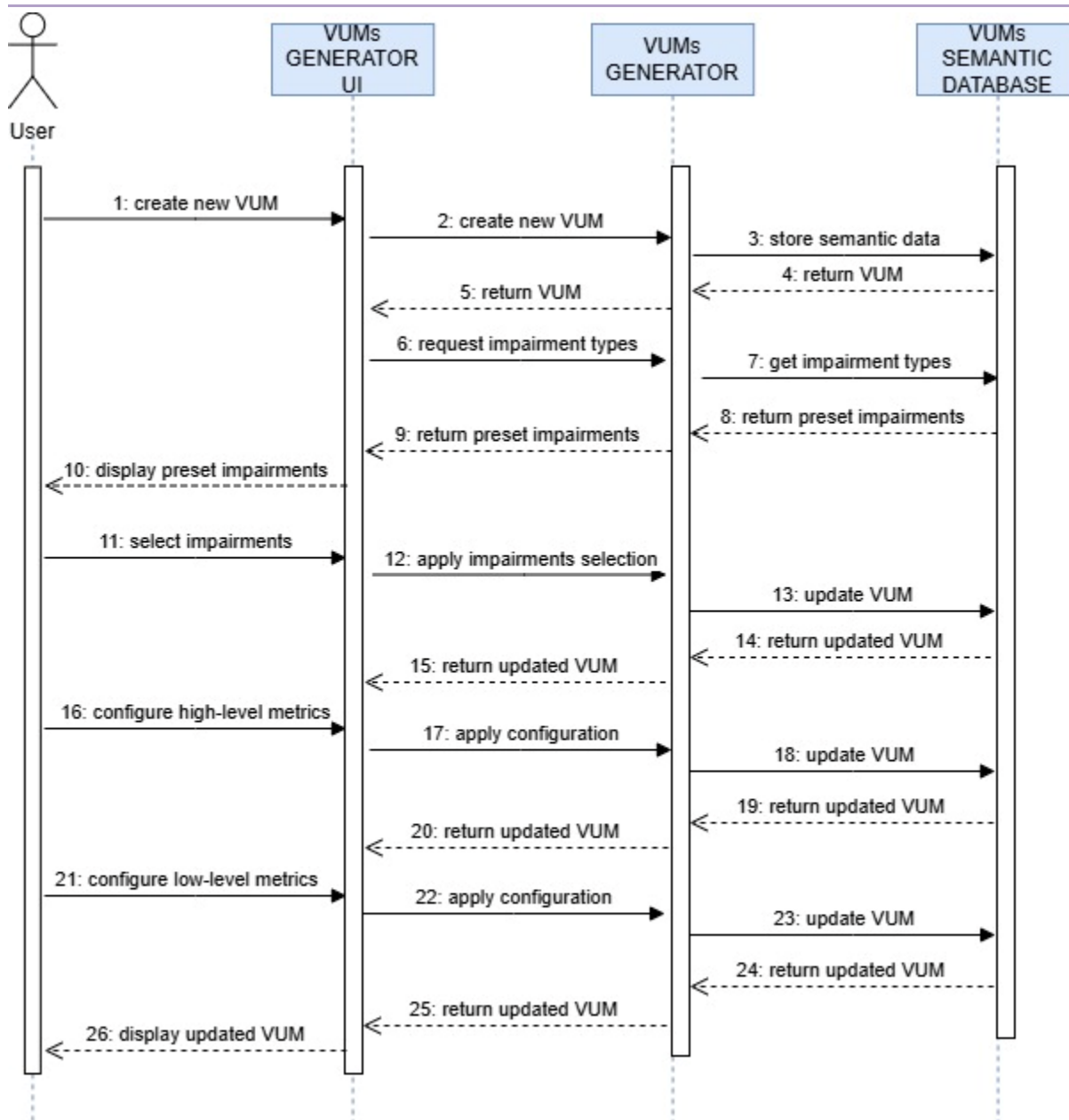


Figure 46. UC4.1 Sequence Diagram

10.4.2 UC4.2: VUM-based Virtual Human authoring

Table 31. UC4.2 Description

Use Case #	UC4.2
Use Case Name	VUM-based Virtual Human authoring
Intent	To create a realistic Virtual Human based on parameters stemming from a selected VUM.

Version/ Author	v1/ FORTH- CERTH
Actors Involved	Main Actor: Building Industry, Professional consultants (e.g., architectural, engineering and financial), Tool developers, Building Material and Product Industries Other: Researchers/ Academia, Environmental/social campaigning organisations, Organisations representing people with disabilities, Potential users/clients for future projects, Public Bodies, EU legislative instruments, Standardization organizations
Brief Description	The actors involved use the provided toolchain to create Virtual Humans (VH) that are the digital representation of each specific VUM in the 3D world. Specifically, the VUM-based Virtual Human Authoring Tool will include the following interactions: 1. The user creates a new VH. 2. The VH UI requests all the available VUMs and pre-existing virtual avatars from the VH generator. 3. The VH generator requests the available VUMs from VUMs generator. 4. The VUMs generator returns the VUMs list to the VH generator. 5. The VH generator requests all the available virtual avatars from the cloud storage server. 6. The cloud storage server returns the virtual avatars list. 7. The VH generator returns all the available VUMs and virtual avatars to the VH UI. 8. The user selects one or more VUMs to apply to the virtual avatar. 9. The VH UI generates the VH based on the selected VUM properties and virtual avatar through the VH generator. 10. The VH generator applies the VUM properties to the virtual avatar. 11. The VH generator creates a new VUM through the VUMs generator. 12. The VUMs generator returns the VUM created. 13. The VH generator returns the updated VH to the VH UI. 14. The VH UI displays the updated VH. 15. The user configures the VH by adjusting VUMs' properties. 16. The VH UI requests update of the generated VH from the VH generator. 17. The VH generator applies the VUM properties to the virtual avatar. 18. The VH generator applies the configurations of VUMs to the VUMs generator. 19. The VUMs generator returns the updated VUM to the VH generator. 20. The VH generator returns the VH to the VH UI. 21. The VH UI displays the updated VH.
Pre-conditions	UC4.1

Trigger	The toolchain can be launched on user demand.
Goal (Successful End Condition)	Create 3D models of Virtual Humans that represent individuals with specific characteristics such as elderly people or people with disabilities
Post Conditions	Virtual Humans are available for 3D Simulation Environments
Related Use Cases	UC.4.3, UC4.4, UC4.5, UC4.6

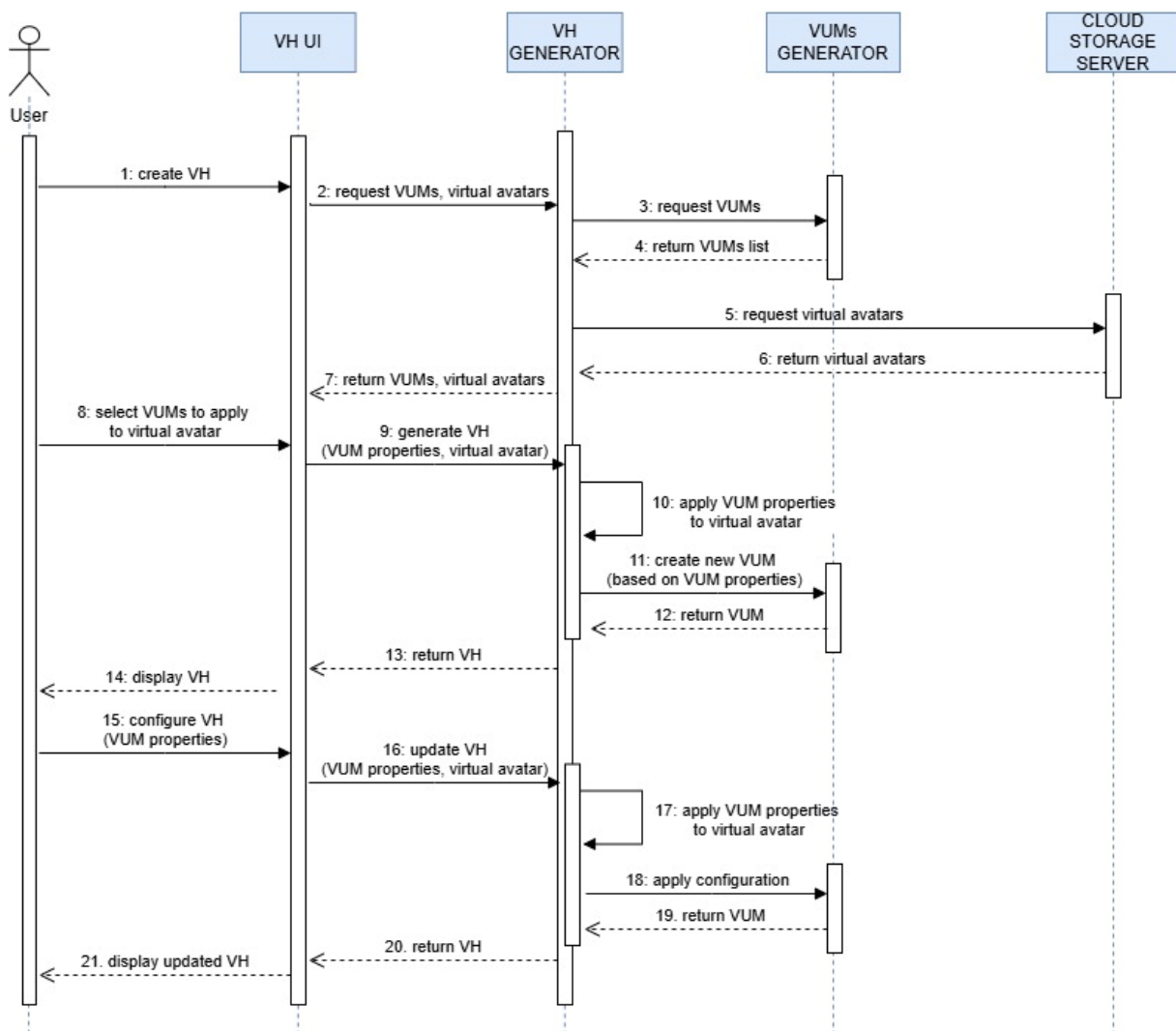


Figure 47. UC4.2 Sequence Diagram

10.4.3 UC4.3: 3D Simulation for Wheelchair building accessibility

Table 32. UC4.3 Description

Use Case #	UC4.3
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Use Case Name	3D Simulation for Wheelchair building accessibility
Intent	To assess building accessibility for wheelchair users
Version/ Author	v1/ FORTH- CERTH
Actors Involved	Main Actor: Engineers, Building/ facility managers Other: Tenants/Owners, Public Bodies, Researchers/ Academics, Software tool Developers, ESCOs
Brief Description	1. User selects and inputs environment data. 2. VH Generator provides VUM-based virtual humans to the Scenario Generator. 3. 3D Env Generator creates a 3D environment from the input data. 4. 3D Env Generator passes the 3D environment to the Scenario Generator. 5. Scenario Generator combines the 3D environment and virtual humans to design the scenario. 6. Scenario Generator sends the scenario for environment modification to the 3D Env Integration Manager. 7. Scenario Generator sends the scenario for VUM Integration to the corresponding Manager component. 8. 3D Env Integration Manager modifies the environment for wheelchair accessibility (ramps, door widths). 9. 3D Env Integration Manager sends the modified environment to the VUM Integration Manager. 10. VUM Integration Manager simulates movement, behavior, and dynamics of wheelchair users in the modified environment. 11. VUM Integration Manager sends simulation results to the Simulation Report Generator. 12. Simulation Report Generator evaluates the simulation for wheelchair accessibility. Simulation Report Generator provides the final report to the user.
Pre-conditions	• UC4.1, UC4.2 • Knowledge about selected VUMs • VUM-based Virtual Humans • 3D Simulation environments along with building documentation. • Accessibility guidelines
Trigger	The 3D simulation can be activated on user demand.
Goal (Successful End Condition)	- Evaluate 3D simulated scenarios against relevant safety and usability standards and provide detailed reports highlighting compliance issues. - Simulate user interactions with the proposed scenarios to identify potential safety hazards and usability issues, supporting testing for different VUMs.

Post Conditions	- A final report evaluating wheelchair accessibility is generated and delivered to the user.
Related Use Cases	UC.4.2, UC4.4, UC4.5, UC4.6

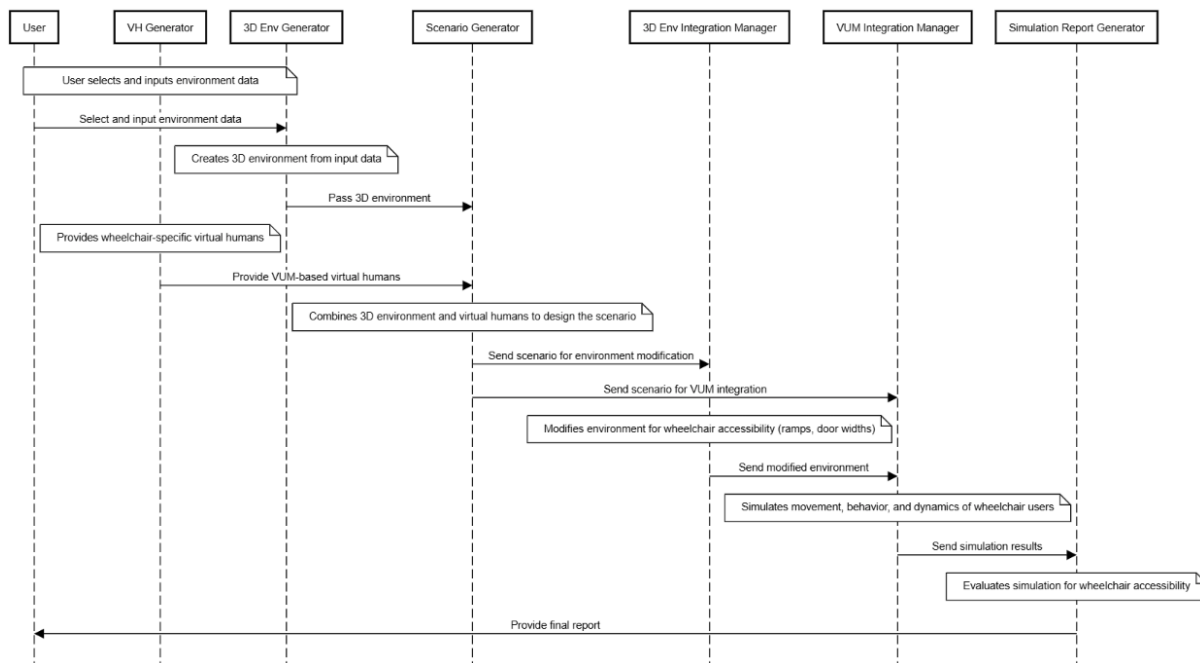


Figure 48 UC4.3 Sequence Diagram

10.4.4 UC4.4: 3D Simulation for building accessibility for the elderly

Table 33. UC4.4 Description

Use Case #	UC4.4
Use Case Name	3D Simulation for building accessibility for the elderly
Intent	To assess building accessibility for the elderly
Version/ Author	v1/ FORTH- CERTH
Actors Involved	Main Actor: Engineers, Building/ facility managers Other: Tenants/Owners, Public Bodies, Researchers/ Academics, Software tool Developers, ESCOs
Brief Description	1. User selects and inputs environment data. 2. VH Generator provides VUM-based virtual humans to the Scenario Generator. 3. 3D Env Generator creates a 3D environment from input data. 4. 3D Env Generator passes the 3D environment to the Scenario Generator.

	5. Scenario Generator combines the 3D environment and virtual humans to design the scenario. 6. Scenario Generator sends the scenario for environment modification to the 3D Env Integration Manager. 7. Scenario Generator sends the scenario for VUM Integration to the corresponding Manager component. 8. 3D Env Integration Manager modifies the environment for elderly-friendly design (handrails, step heights). 9. 3D Env Integration Manager sends the modified environment to the VUM Integration Manager. 10. VUM Integration Manager simulates movement, behavior, and dynamics of elderly users in the modified environment. 11. VUM Integration Manager sends simulation results to the Simulation Report Generator. 12. Simulation Report Generator evaluates the simulation for elderly accessibility. Simulation Report Generator provides the final report to the user.
Pe-conditions	• UC4.1, UC4.2 • Knowledge about selected VUMs • VUM-based Virtual Humans • 3D Simulation environments along with building documentation. • Accessibility guidelines
Trigger	The assessment tool can be activated on user demand.
Goal (Successful End Condition)	- Evaluate 3D simulated scenarios against relevant safety and usability standards and provide detailed reports highlighting compliance issues. - Simulate user interactions with the proposed scenarios to identify potential safety hazards and usability issues, supporting testing for different VUMs. - Analyze simulation results to provide recommendations for design improvements.
Post Conditions	- A final report evaluating wheelchair accessibility is generated and delivered to the user.
Related Use Cases	UC.4.2, UC4.3, UC4.5, UC4.6

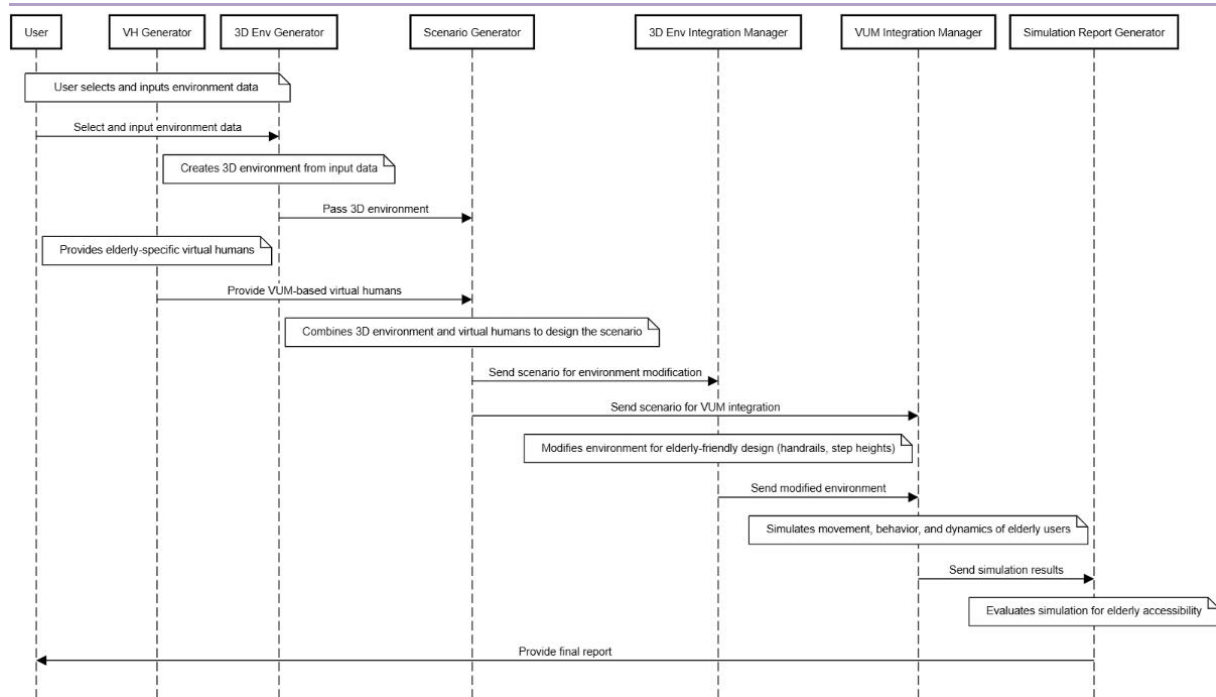


Figure 49 UC4.4 Sequence Diagram

10.4.5 UC4.5: 3D Simulation for building accessibility for visually impaired people

Table 34 . UC4.5 Description

Use Case Name	3D Simulation for building accessibility for visually impaired people
Intent	To assess building accessibility for visually impaired people
Version/ Author	v1/ FORTH- CERTH
Actors Involved	Main Actor: Engineers, Building/ facility managers Other: Tenants/Owners, Public Bodies, Researchers/ Academics, Software tool Developers, ESCOs
Brief Description	1. User selects and inputs environment data. 2. VH Generator provides VUM-based virtual humans to the Scenario Generator. 3. 3D Env Generator creates a 3D environment from input data. 4. 3D Env Generator passes the 3D environment to the Scenario Generator. 5. Scenario Generator combines the 3D environment and virtual humans to design the scenario. 6. Scenario Generator sends the scenario for environment modification to the 3D Env Integration Manager. 7. Scenario Generator sends the scenario for VUM Integration to the corresponding Manager component.

	8. 3D Env Integration Manager modifies the environment for visually impaired accessibility (tactile paths, braille signs). 9. 3D Env Integration Manager sends the modified environment to the VUM Integration Manager. 10. VUM Integration Manager simulates movement, behavior, and dynamics of visually impaired users in the modified environment. 11. VUM Integration Manager sends simulation results to the Simulation Report Generator. 12. Simulation Report Generator evaluates the simulation for visually impaired accessibility. Simulation Report Generator provides the final report to the user.
Pre-conditions	• UC4.1, UC4.2 • Knowledge about selected VUMs • VUM-based Virtual Humans • 3D Simulation environments along with building documentation. • Accessibility guidelines
Trigger	The assessment tool can be activated on user demand.
Goal (Successful End Condition)	- Evaluate 3D simulated scenarios against relevant safety and usability standards and provide detailed reports highlighting compliance issues. - Simulate user interactions with the proposed scenarios to identify potential safety hazards and usability issues, supporting testing for different VUMs. - Analyze simulation results to provide recommendations for design improvements.
Post Conditions	- A final report evaluating visually impaired accessibility is generated and delivered to the user.
Related Use Cases	UC.4.2, UC4.3, UC4.4, UC4.6

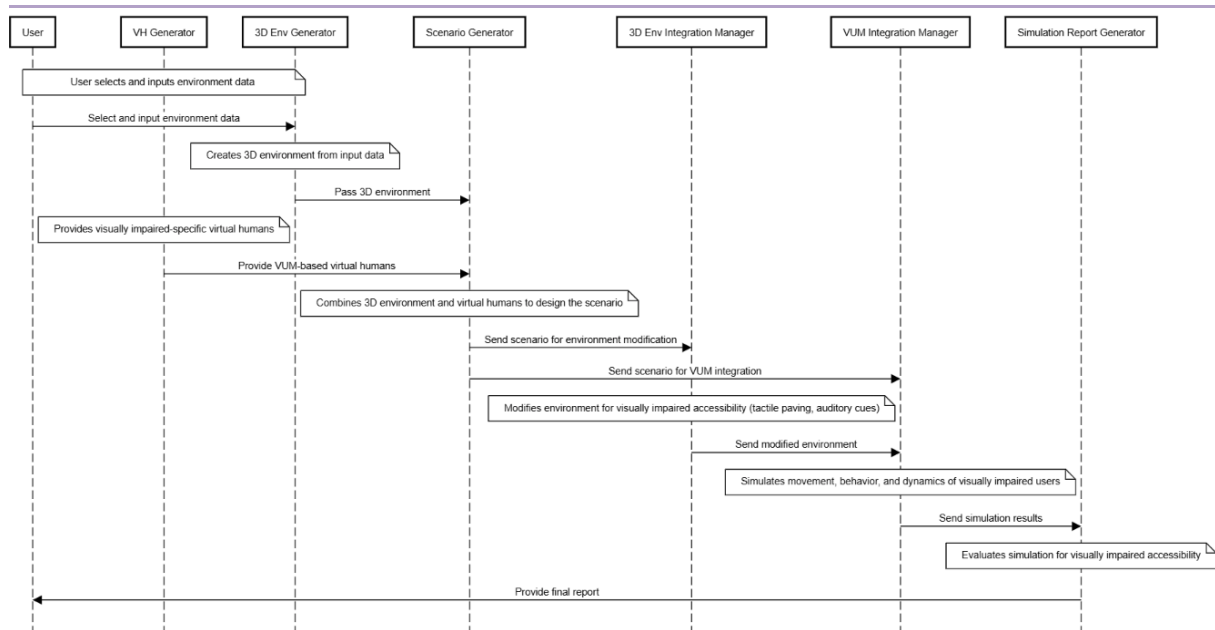


Figure 50 UC4.5 Sequence Diagram

10.4.6 UC4.6: 3D Simulation for building accessibility for auditory impaired people

Table 35. UC4.6 Description

Use Case #	UC4.6
Use Case Name	3D Simulation for building accessibility for auditory impaired people
Intent	To assess building accessibility for auditory impaired people
Version/ Author	v1/ FORTH- CERTH
Actors Involved	Main Actor: Engineers, Building/ facility managers Other: Tenants/Owners, Public Bodies, Researchers/ Academics, Software tool Developers, ESCOs
Brief Description	1. User selects and inputs environment data. 2. VH Generator provides VUM-based virtual humans to the Scenario Generator. 3. 3D Env Generator creates a 3D environment from input data. 4. 3D Env Generator passes the 3D environment to the Scenario Generator. 5. Scenario Generator combines the 3D environment and virtual humans to design the scenario. 6. Scenario Generator sends the scenario for environment modification to the 3D Env Integration Manager.

	7. Scenario Generator sends the scenario for VUM Integration to the corresponding Manager component. 8. 3D Env Integration Manager modifies the environment for auditory impaired accessibility (visual alerts, sign language support). 9. 3D Env Integration Manager sends the modified environment to the VUM Integration Manager. 10. VUM Integration Manager simulates movement, behavior, and dynamics of auditory impaired users in the modified environment. 11. VUM Integration Manager sends simulation results to the Simulation Report Generator. 12. Simulation Report Generator evaluates the simulation for auditory impaired accessibility. Simulation Report Generator provides the final report to the user.
Pre-conditions / Assets of the UC	• UC4.1, UC4.2 • Knowledge about selected VUMs • VUM-based Virtual Humans • 3D Simulation environments along with building documentation. • Accessibility guidelines
Trigger	The assessment tool can be activated on user demand.
Goal (Successful End Condition)	- Evaluate 3D simulated scenarios against relevant safety and usability standards and provide detailed reports highlighting compliance issues. - Simulate user interactions with the proposed scenarios to identify potential safety hazards and usability issues, supporting testing for different VUMs. - Analyze simulation results to provide recommendations for design improvements.
Post Conditions	- A final report evaluating auditory impaired accessibility is generated and delivered to the user.
Related Use Cases	UC.4.2, UC4.3, UC4.4, UC4.5

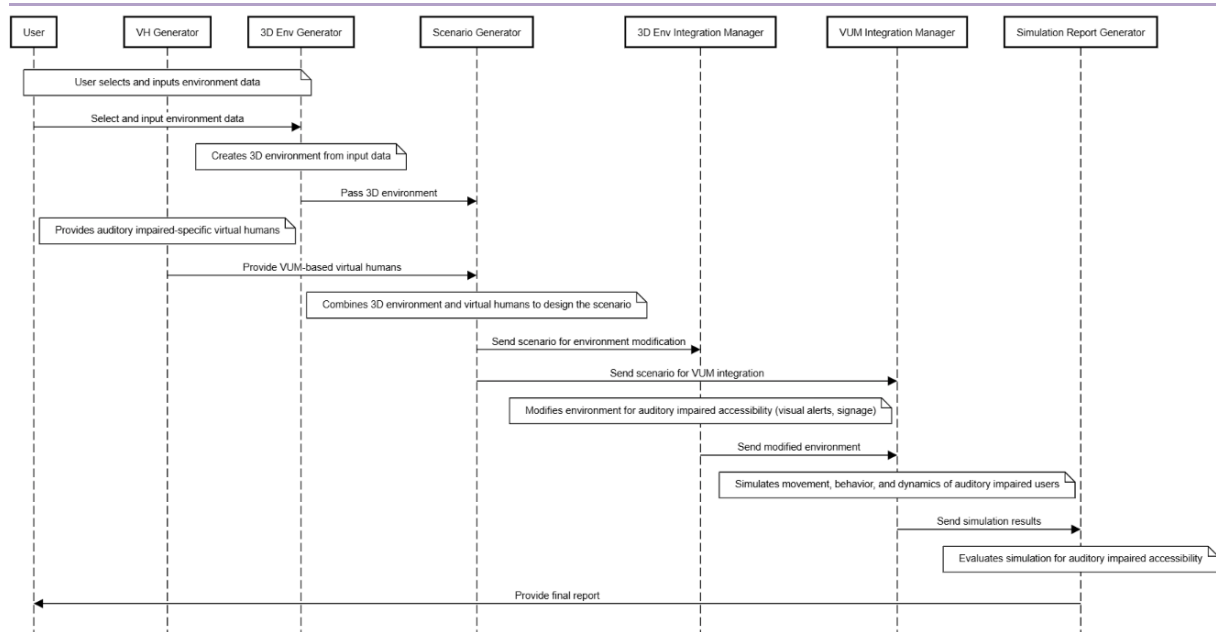


Figure 51 UC4.6 Sequence Diagram

10.5 BS5: Monitor and Optimize building operation

10.5.1 UC5.1: Provide information (real-time/ historical) on building's energy performance

Table 36. UC5.1 Description

Use Case #	UC5.1
Use Case Name	Provide real-time/historical information on building's energy performance
Intent	To provide information (real time/historical data) on the building's energy usage and production, helping users manage and improve energy efficiency.
Version/ Author	v1/ CERTH
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	1. The process begins when the user submits a request for real-time or historical energy data via the BOMS UI. 2. The BOMS UI forwards the user's request to the Energy Monitoring System. 3. The Energy Monitoring System sends a request to the Information Management Layer for the required energy data.

	4. The Information Management Layer retrieves the requested data and sends it back to the Energy Monitoring System. 5. The Energy Monitoring System processes the retrieved data in order to format it correctly for presentation in the required graph formats. 6. The processed energy consumption and generation data is displayed to the user via the BOMS UI, enabling informed analysis and decision-making.
Pre-conditions	Smart meters and IoT devices must be installed and functional.
Trigger	Request to view energy performance data.
Goal (Successful End Condition)	Users can see real-time/historical energy data and use it to optimize building operations for better energy efficiency.
Post Conditions	- Building's energy performance data is recorded and stored. - Users may adjust building operations to improve efficiency.
Related Use Cases	UC5.2, UC5.3

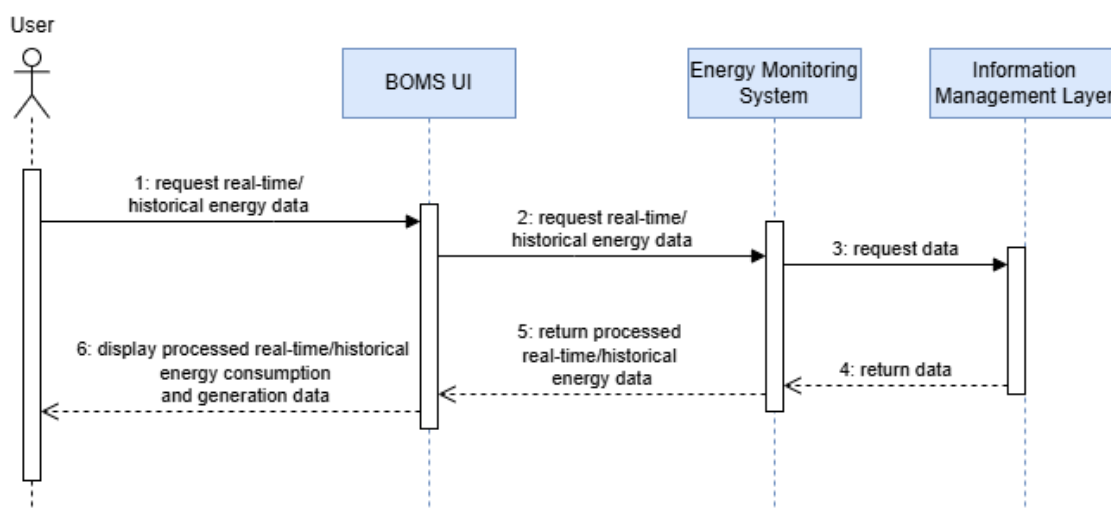


Figure 52 UC 5.1 Sequence Diagram.

10.5.2 UC5.2: Provide real-time/historical information on building's indoor conditions

Table 37. UC5.2 Description

Use Case #	UC5.2
Use Case Name	Provide real-time/historical information on building's indoor conditions

Intent	To provide live and historical data on indoor conditions (temperature, humidity, air quality, etc.) for monitoring and improving user comfort.
Version/ Author	v1/ CERTH
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	1. The process begins when the user submits a request for real-time or historical building condition data via the BOMS UI. 2. The BOMS UI forwards the user's request to the Energy Monitoring System. 3. The Energy Monitoring System sends a request to the Information Management Layer for the required data. 4. The Information Management Layer retrieves the requested data and sends it back to the Energy Monitoring System. 5. The Energy Monitoring System processes the retrieved data in order to format it correctly for presentation in the required graph formats. 6. The processed building condition data is displayed to the user via the BOMS UI, enabling informed analysis and decision-making.
Pre-conditions	IoT sensors installed and functional for monitoring indoor conditions.
Trigger	Request to monitor building conditions in real time.
Goal (Successful End Condition)	Users can view live indoor environmental data and make informed adjustments to maintain comfort and health standards.
Post Conditions	- Indoor condition data is continuously monitored and stored. - Building operations may be adjusted based on data insights for improved comfort.
Related Use Cases	UC4.2, UC5.1, UC5.3

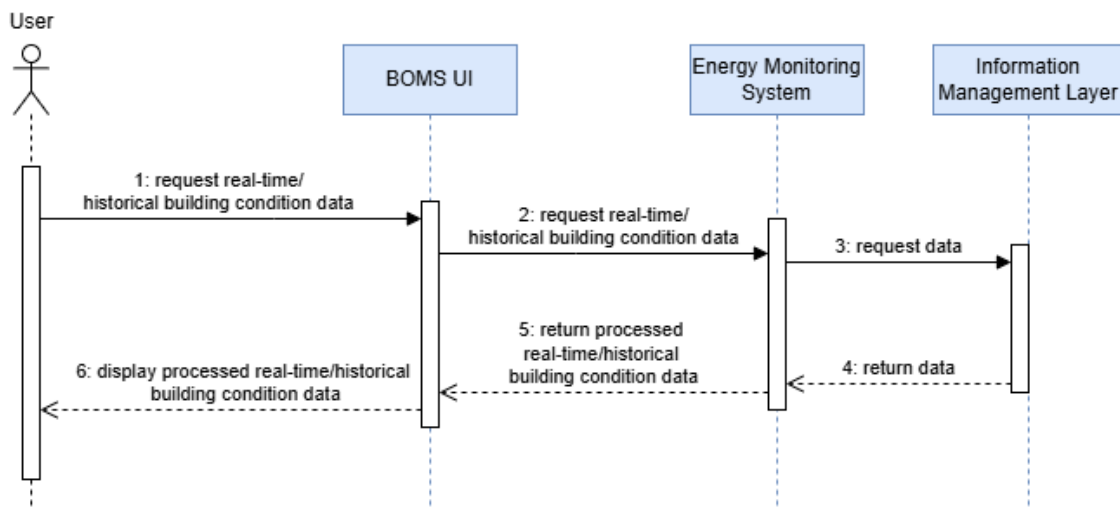


Figure 53 UC 5.2 Sequence Diagram

10.5.3 UC5.3: Provide recommendation for improving operational energy performance & conditions in terms of health and comfort

Table 38. UC5.3 Description

Use Case #	UC5.3
Use Case Name	Provide recommendation for improving operational energy performance & conditions in terms of health and comfort
Intent	To provide actionable recommendations for optimizing energy performance and improving building indoor conditions based on real-time data.
Version/ Author	v1/ CERTH
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	1. The process begins when the user requests building recommendations via the BOMS UI. 2. The BOMS UI requests historical data and optimization inputs necessary for the analysis. 3. The Adaptive Building Optimizer queries external APIs for weather data and energy price information. 4. External APIs return the requested weather and energy price data.

	5. The Adaptive Building Optimizer requests an energy forecast based on the gathered data. 6. Historical energy data is requested from the Information Management Layer. 7. The Information Management Layer returns the requested historical energy data. 8. The AI Powered Energy Forecasts provide the forecasts for energy consumption and generation using the historical data. 9. The energy consumption and generation forecasts are written to the database for storage. 10. The forecasts are returned to the Adaptive Building Optimizer for further processing. 11. The system requests real-time comfort levels from the Energy Comfortness Tool. 12. The Energy Comfortness Tool calculates the current comfort levels based on real-time data. 13. The comfort levels are returned to the Adaptive Building Optimizer. 14. The Adaptive Building Optimizer requests real-time energy data from the Information Management Layer. 15. The real-time energy data is returned by the Information Management Layer. 16. The Adaptive Building Optimizer performs an optimization process, integrating energy prices, weather data, energy forecasts, comfort level and real-time data to generate actionable recommendations. 17. The optimization results are written to the database for storage. 18. The building recommendations, generated from the optimization process, are returned to the BOMS UI. 19. Finally, the building recommendations are displayed to the user via the BOMS UI for implementation.
Pre-conditions	- Real-time/historical data on energy performance and indoor conditions is being collected - Access to external data of energy prices - Access to external data of weather data
Trigger	Request recommendations for improving energy efficiency and indoor comfort based on current conditions.
Goal (Successful End Condition)	Users receive optimized recommendations to enhance both energy performance and indoor conditions, which they can act upon to improve building operations.
Post Conditions	Users receive optimized recommendations to enhance both energy performance and indoor conditions, which they can implement to improve building operations.
Related Use Cases	UC4.2, UC5.1, UC5.2

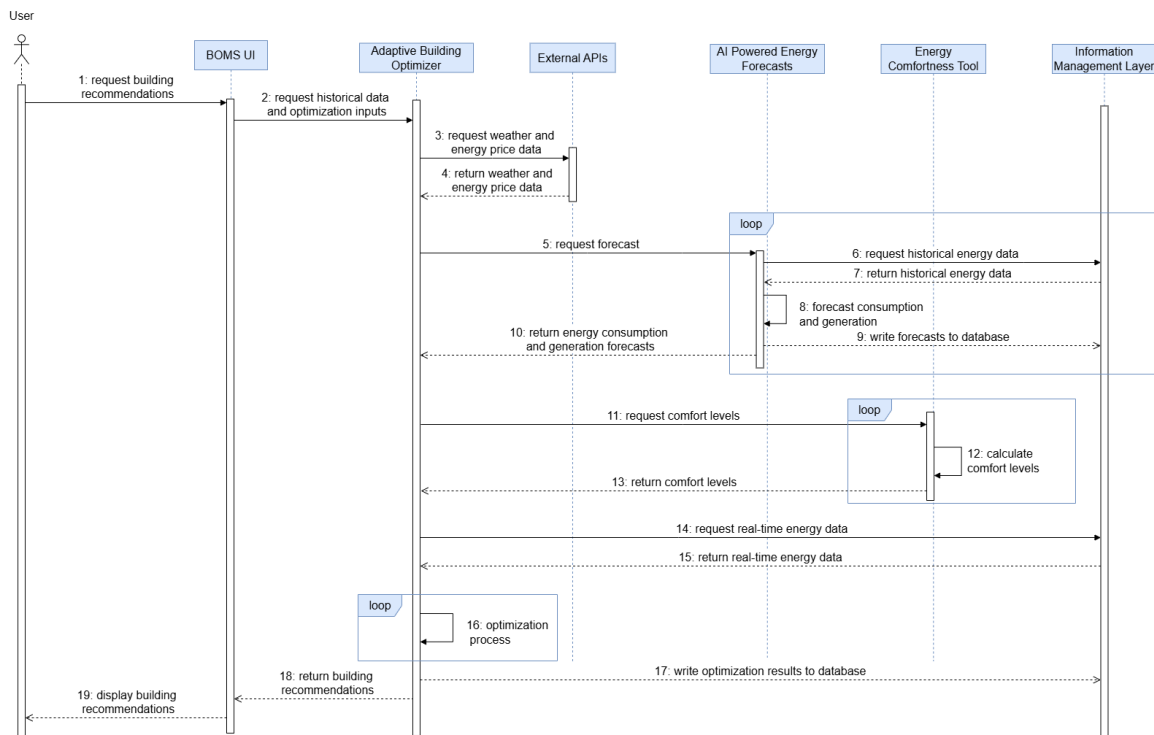


Figure 54 Use Case 5.3 Sequence Diagram.

10.5.4 UC5.4: GIS visualization of accessibility features

Table 39. UC5.4 Description

Use Case #	UC5.4
Use Case Name	GIS visualisation of building accessibility features
Intent	To visualize the building's accessibility features of the surrounding area using GIS, enabling users to manage and assess the accessibility aspects of the neighbourhood in a location-specific manner.
Version/ Author	v1/ DMO
Actors Involved	Main Actor: Engineers, Building designers, Building/ Facility Managers Other: Tenants/Owners, End-Users, Public Bodies, Software Developers, ESCOs, Researchers/ Academics.
Brief Description	This use case provides a GIS-based visualization of accessibility features in the area to help users manage accessibility compliance and address potential improvements based on location-specific insights.

Pre-conditions	- Technical infrastructure - Access to external data of accessibility information in the area
Trigger	A user accesses the GIS system to visualize building surroundings' accessibility information.
Goal (Successful End Condition)	Users can view the building's surrounding accessibility features on a GIS interface, helping people with disabilities to understand how to navigate the area safely and efficiently. Goals of this use case are enhanced accessibility, promotion of inclusivity, and improved planning.
Post Conditions	- Users gain insights into the accessibility features through a spatial interface. - Accessibility data is updated in the GIS system. - Accessibility improvement areas can be identified and addressed based on location-specific analysis.
Related Use Cases	UC5.1, UC5.2, UC5.3

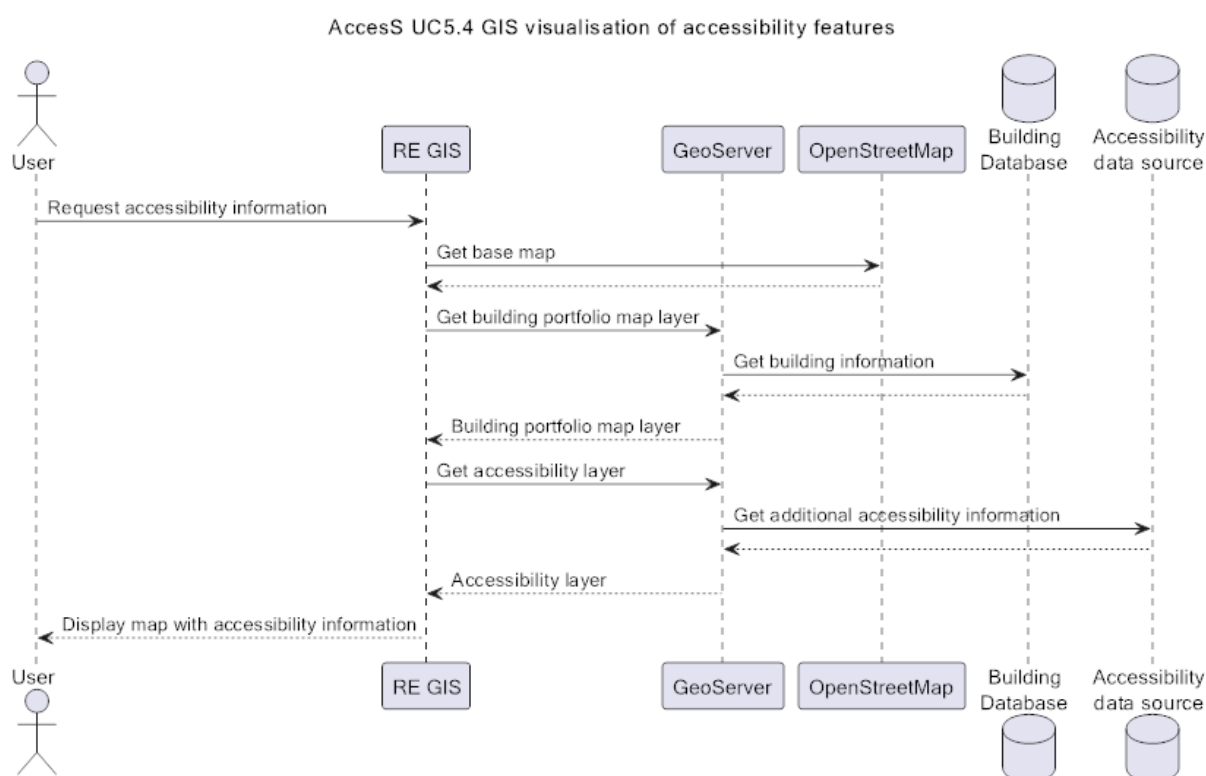


Figure 55 Use Case 5.4 Sequence Diagram

10.6 BS6: Integrate Electric Vehicles as Active Building Element

10.6.1 UC6.1: Optimize EV Charging in Building Infrastructure

Table 40. UC6.1 Description

Use Case #	UC6.1
Use Case Name	Optimise EV Charging in Building Infrastructure
Intent	To optimise EV charging by managing load distribution within a building's energy system, preventing peak-hour congestion and enhancing grid resilience. The system focuses on ensuring charging efficiency and energy conservation while catering to user-specific needs, particularly for people with disabilities and the elderly.
Version/ Author	v1/ HIVE
Actors Involved	Main Actors: Building Managers, Facility Managers, EV Owners Other Actors: Engineers, Public Bodies, Software Developers, Researchers/Academics, Energy Providers
Brief Description	1) The EV owner or building manager (user) sets the charging preference and the accessibility conditions to the building EV charging system 2) The EV is plugged in the building's EV charging system and is ready for the initiation of the charging process 3) Charger, EV and User preferences are communicated as input to the predictive algorithm 4) Building energy demand is communicated as input to the predictive algorithm 5) Energy tariff information is communicated into the predictive algorithm to optimize the energy cost for charging 6) Real-time updates on the grid condition and grid demand are communicated to the predictive algorithm 7) The predictive algorithm calculates and dynamically adjusts the charging schedule based on real-time grid conditions, energy cost, user preferences (with a focus on accessibility) and EV/charger specific needs. 8) Personalized EV charging patterns are communicated to the charging system 9) Adjusted dynamic scheduling is actuated at the EV level. 10) Users (building manager and EV owners) can monitor the charging process and the given recommendations for the best charging times
Pre-conditions	EV charging stations, real-time data on grid load, user profile data, energy pricing information, IoT devices for real-time monitoring.

Trigger	The request for EV charging optimisation is triggered when an EV is plugged into the building's charging station, or when a significant change in grid demand is detected.
Goal (Successful End Condition)	Achieve efficient, balanced EV charging, minimising grid overload during peak hours, and improving user convenience, with special considerations for people with disabilities and the elderly.
Post Conditions	The system adapts to fluctuating energy conditions, while also considering individual users' needs, particularly those who may require additional assistance.
Related Use Cases	UC5.1, UC5.3

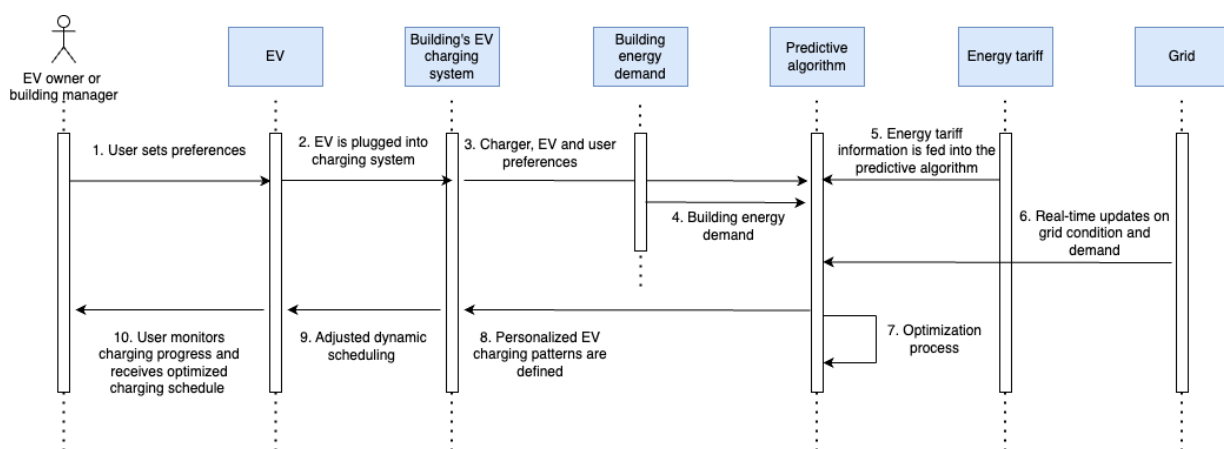


Figure 56 Sequence Diagram of UC6.1

10.6.2 UC6.2: Enable EVs to Act as Distributed Energy Resources (DERs)

Table 41. UC6.2 Description

Use Case #	UC6.2
Use Case Name	Enable EVs to Act as Distributed Energy Resources (DERs)
Intent	To utilise EVs as dynamic energy storage units that can supply energy back into the building grid, reducing energy costs and supporting grid stability during peak demand periods.
Version/ Author	v1/ HIVE
Actors Involved	Main Actors: Building Managers, Facility Managers, EV Owners

	Other Actors: Engineers, Public Bodies, Software Developers, Researchers/Academics, Energy Providers
Brief Description	The following description is applicable only if bi-directional charger and bi-directional vehicles are available and accessible on site. The flow follows the same structure as UC 6.1 with the only difference of bi-directional flow between the EV and the building (in red in the diagram below). 1) The EV owner or building manager (user) sets the charging preference and the accessibility conditions to the EV charging system. 2) The EV is plugged in the building's EV charging system and is ready for the initiation of the charging process 3) Charger, EV and User preferences are communicated as input to the predictive algorithm 4) Building energy demand is communicated as input to the predictive algorithm 5) Energy tariff information is communicated into the predictive algorithm to optimize the energy cost for charging 6) Real-time updates on the grid condition and grid demand are communicated to the predictive algorithm 7) The predictive algorithm calculates and dynamically adjusts the charging schedule based on real-time grid conditions, energy cost, user preferences (with a focus on accessibility) and EV/charger specific needs 8) Personalized EV charging patterns are communicated to the charging system: the charging pattern may be bi-directional if the predictive algorithm calculates that it is more convenient to feed the energy back into the building from the EV instead of taking energy from the grid. 9) Adjusted dynamic scheduling is actuated at the EV level. 10) Users (building manager and EV owners) can monitor the charging process and the given recommendations for the best charging times
Pre-conditions	EVs with bi-directional charging capabilities, real-time data on building energy demand, IoT devices for monitoring energy usage, availability of DER management software.
Trigger	Request for energy supply from EVs
Goal (Successful End Condition)	To successfully use EVs as distributed energy resources (DERs), reducing energy costs and stabilising the grid during periods of high demand, without compromising EV charging needs.
Post Conditions	The system should ensure that the energy levels of EVs are sufficient for both driving and energy supply purposes, providing updates to vehicle owners to maintain transparency.
Related Use Cases	UC6.1, UC5.1, UC5.3

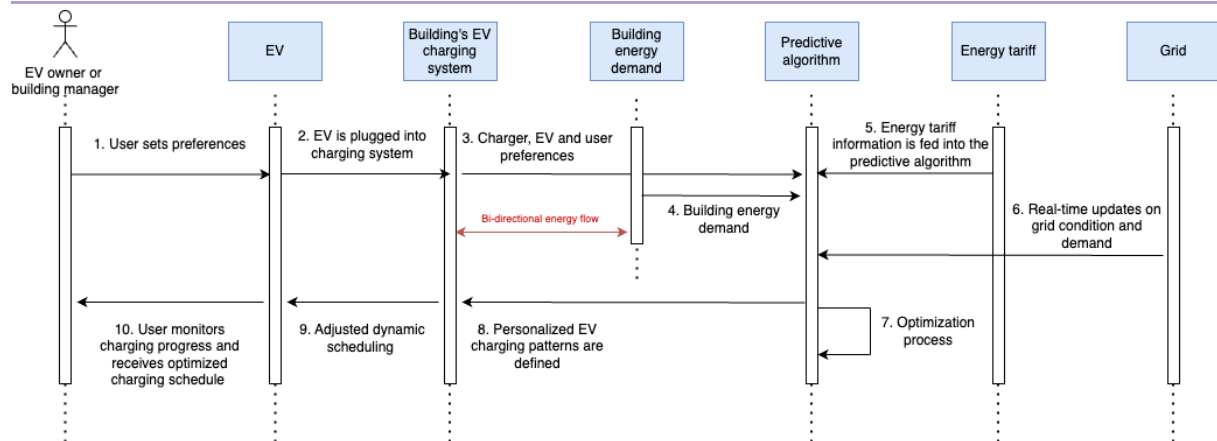


Figure 57 Sequence Diagram of UC6.2

11 Conclusions

Deliverable D1.2 includes a more detailed analysis of the project pilot sites and highlights the current conditions of each site and targets set. This report also serves as the primary deliverable for defining the AccesS architecture in detail, aligning with the three pillars of project development. It outlines the system's components, key functionalities, and technical specifications, ensuring alignment with user requirements.

A thorough analysis of the six pilot sites was carried out as part of T1.2, trying to address numerous types of uses and real-life situations and challenges in accessibility that people face under common use case scenarios in order to maximize project's impact for end-users with disabilities and older people. In more details, the Christo and Jeanne-Claude Center in Gabrovo, Bulgaria which was a former vocational textile high-school, will become an exhibition center featuring the work of Christo and Jeanne-Claude. The renovation project also envisions the transformation of the riverside zone through the reshaping of the riverbed area and modelling of the banks, renovating and creating a pedestrian path with resting areas, creating zones for sports, recreation and outdoor cultural activities. The Brancacci Chapel, in Florence, Italy is located within the Church of Santa Maria del Carmine in Florence, is renowned for its exceptional frescoes by Masaccio, Masolino, and Filippino Lippi, marking a pivotal moment in Early Renaissance art. Environmental monitoring of the chapel coupled with the number of visitors is of particular interest, considering also the conservation status of wall paintings and wall structures with the goal to allow the implementation of virtual inspection. Located in the heart of Naaldwijk, Netherlands, the Droom Je Thuis house offers its 12 residents with intellectual or multiple disabilities the opportunity to live independently while ensuring that care and family are always nearby. The building is rather recent with a wide variety of smart sensors and RES already installed and coupling with BOMS is of particular interest to connect PVs, heat pumps, climate control system, weather forecast, EV charging station and energy rates into an integrated system. Moreover, Casa Girasole in Massagno, Switzerland, has been operational since September 2002 as a non-hospital healthcare facility, and is committed to offering a safe and welcoming environment, ensuring that residents receive the necessary care and support to maintain their well-being and quality of life. The needs and requirements in terms of energy comfort of these types of users is different from the average usage patterns and values while the pilot is also interested in improving the parking area in the front of the building with accessible infrastructure that includes EV charging points, for workers or visitors with reduced mobility. In addition, the Palazzo di Città located in the city center of Bari, Italy hosts the main municipal offices since 1860. Recognizing the building's significant social and cultural value, a comprehensive energy efficiency project has been developed with interventions aimed at improving the energy performance of the fixtures, the distribution system of the summer and winter air conditioning systems and the MV/LV energy distribution system of the internal lighting. AccesS project will complement the forthcoming executive project with special focus on the accessibility of the physically impaired people and comfortness of the working environment. Last, the Mercado de Veronicas in Murcia, Spain is a municipal market built between 1912 and 1916 by Pedro Cerdán Martínez. The building is currently under renovation with the restoration of facades, replacement of exterior carpentry, waste management and underground electrical installations. The objectives for the market would be to increase the digitalization of the building safeguarding the experience for elderly customers as well as flatten the visitors presence curve to offer a more pleasant and stress-free shopping experience, enhanced via real-time accessible information on shops location, working hours and services as escalators, elevators, toilets etc. Additional useful information for the users are environmental conditions of the inner areas of the market as humidity, temperature, air quality and lighting, to enhance accessibility and ensure user comfort.

As part of the activities of T1.3, this report also defines system architecture, functional modules, interfaces, data models, and technical requirements to support integration and independent

development. In particular, the system architecture design methodology used in this project follows a structured system on based practices defined from established standards and frameworks. This methodology ensures a clear and organized process for defining the AccesS architecture through multiple viewpoints (perspectives).

- The Functional View defines the system's core functional components, their roles, and key functionalities.
- The Information View describes how data and information flow between various digital tools, ensuring efficient communication and integration.
- The Deployment View specifies module requirements and the necessary hardware infrastructure for deployment.
- The Dynamic View illustrates how system components operate, their functionalities, and interactions within the runtime environment.

This design phase also incorporates both functional and non-functional requirements of the system. Functional requirements specify the system's features and expected behaviour, while non-functional requirements address aspects such as performance, security, scalability and usability. This ensures the system architecture meets all technical and operational needs effectively.

Finally, the system architecture, along with the relevant system requirements, pilot needs, and the three pillars, served as the foundation for defining business scenarios. These scenarios guided the identification and extraction of corresponding use cases, which were analysed in detail and represented through sequence diagrams. Each responsible partner presented the component's internal architecture, functionalities, interaction with other components and provided the respective use case.

As the project continues and the technical work packages advance, the technical aspects of all involved digital tools will become more refined and specific as part of the respective tools development activities within WP4-WP7. Consequently, future deliverables will provide more detailed descriptions related to the development and implementation of each tool within the AccesS Suite. Certain aspects will also be evaluated and refined to ensure optimal functionality and integration.

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