RINNO PROJECT

Report

An augmented intelligence-enabled stimulating framework for deep energy renovation delivering occupant-centred innovations

Deliverable 1.8: Architecture of RINNO Suite along with its Functional Technical Specifications v1

Work Package 1: RINNO Augmented Intelligence Renovation Framework

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Executive Summary

This deliverable introduces the initial version of RINNO architecture, released at M9. The two next updated versions will be released at M24 and M36.

Firstly, the document describes the way and the procedure used to document the architecture. Specifically, the design process of the architecture is divided in three phases namely, technology exploration, bottom-up and top-down. In the first phase, there is an analysis of similar projects to RINNO, both EU funded and regional, to explore critical technological features for the architecture designing. Secondly in the bottom-up phase, the technologies and the components brought by individual partners are gathered. After the identification of any missing modules or functionalities, the definition of architecture begins. In the final phase, the role, the interactions, and the aspects of each component are analysed by utilizing the use cases. The top-down phase will be better presented in the updated versions of this document.

The documentation of the architecture follows the standard IEEE 1471 "Recommended Practice for Architectural Description for Software-Intensive Systems"[1]. The designing process that this standard implies is based on different architecture viewpoints. For the RINNO architecture three architecture viewpoints have been used, namely functional view, deployment view and information view.

The functional view defines the components, their functionality, and their interactions. The main identified architecture components are:

- Multi - Sensorial Network consists of heterogeneous devices (e.g. energy smart meters, indoor environmental conditions, occupancy, etc.) that allows the interaction between the physical world (building related information) and the platform.
- Renovation Repository includes State of the Art, conventional and innovative renovation solutions, and technologies, like RES, hybrid, and Storage solutions etc.
- Planning & Design Assistant is a tool that helps involved stakeholders (e.g., owners, designers, architects, etc.) to make proper and justified decisions (optimum renovation solution/ scenario) on how to plan and design the building's renovation, based on performance simulations followed by an extensive assessment according to relevant KPIs (Key Performance Indicators).
- Retrofitting Manager is a tool that helps execution, analysis, monitoring and management of the renovation process, along with construction strategies, process industrialization and optimization techniques based on best practices for the off-site construction and on-site automation.
- Building Lifecycle Renovation Manager follows up the renovation process through its whole life cycle and assists users during the process and monitors various aspects of building performance and occupants' comfort as well as operations during building lifetime deciding on optimal strategies/ decisions to maximize energy efficiency.
- Renovation Workflow & Transactions Manager. It is a cloud-based tool that enables the entire renovation value chain, organizes the information exchange between the various

[1] IEEE Standard 1471-2000 (2000), IEEE Recommended Practice for Architectural Description of Software-Intensive Systems

components, provides verification libraries that enable the automation quality assurance of processes, and ensures the transparency of quality transaction contracts and data provenance.

- Operational Interface with Augmented Intelligence is formed by the other main components and is an occupant-centred approach that can monitor and facilitate the whole lifecycle of building renovation. It is also used to provide information exchange, and a more personalized experience to the participants.
- Middleware Infrastructure is the "glue" of the system, which ensures connectivity with heterogeneous physical devices and allows data exchange among the components of the platform.

The deployment view defines how and where the system will be deployed. It also describes the hardware or the software requirements, the dependencies, and the physical restrictions.

The information view describes the flow and the distribution of the information, as well as the application domain models.

Finally, RINNO suite will be deployed under real conditions at four large demo sites (pilot buildings), that will cover different market needs and climate zones located in France, Denmark, Greece, and Poland.

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Abbreviations List

AEC	Architecture, Engineering & Construction
AHP	Analytical Hierarchy Process
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
BEMS	Building Energy Management System
BIM	Building Information Model
BLRM	Building Lifecycle Renovation Manager
BoQ	Bill of Quantities
BRPs	Building Renovation Passports
CAD	Computer-Aided design
CIM	Common Information Model
CIT	Common Information Translator
CPU	Central Processing Unit
CSS	Cascading Style Sheet
DLT	Distributed Ledger Technologies
DoPW	Digital Plan of Work
DRIP	Deep Renovation Digital Plan
EU	European Union
GB	Giga Byte
GHG	Greenhouse Gases
GPU	Graphics Processing Unit
HMI	Human Machine Interface
HTML	Hyper-Text Markup Language
IAI	International Alliance for Interoperability

IAM	Identity and Access Management
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
PC	Personal Computer
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluations
PV	Photo Voltaic
RAM	Random Access Memory
RES	Renewable Energy Source
RMCP	RINNO Marketplace & Collaboration Platform
ROM	Read-Only Memory
RPDA	RINNO Planning & Design Assistant
RRM	RINNO Retrofitting Manager
RRR	RINNO Renovation Repository
RWM	Renovation Workflow Manager
RWTM	Renovation Workflow & Transactions Manager
SCB	Smart Connected Buildings
S-LCA	Social Life Cycle Assessment
SQL	Standardized Query Language
TEA	Techno-economical Assessment
UI	User Interface
UML	Unified Modelling Language
USB	Universal Serial Bus
VR	Virtual Reality

WP	Work Package

1. Introduction

This chapter defines the objectives, the context, and the structure of the deliverable. It also outlines its background.

1.1 Scope, Context and Structure of this deliverable.

This deliverable introduces the initial version of RINNO's architecture. Some component of the architecture will be verified during the development of the project, in this framework it is reasonable that some of the system requirements will be updated. The second version of the architecture will be delivered at M24 and the final at M36. This deliverable specifies a set of hardware and software requirements and describes the features of main components. Moreover, the architecture of the system includes the interfaces of the components and the way they should interact among them.

Within Chapter 2 of the deliverable the approach that was followed to design the architecture has been defined. In the three following chapters, the views of the architecture are presented, namely functional view (Chapter 3), information view (Chapter 4) and deployment view (Chapter 5), respectively. In the final chapter, the conclusions of the document are depicted.

1.2 Background

RINNO aims to deliver a framework solution for deep energy renovation. The prime goal is to develop an occupant-centred operational interface with augmented intelligence for all the phases of building renovation (planning-design, retrofitting, monitoring). More specifically, RINNO gathers the requirements of the stakeholders, as well as the features of the building, and provides a set of efficient solutions, from its Renovation Repository. During the design phase, a range of applicable scenarios are generated upon a virtual representation of the building (Digital-Twin). RINNO introduces a Decision Support System to assist users choosing the optimal scenarios, according to Key Performance Indicators. During the retrofitting phase, the system proposes a variety of tools and methods to reduce installation time and cost, and occupant's disturbance. Those tools and methods include novel construction offsite and onsite strategies to optimize logistics and installation processes, as well as AR devices to facilitate on-the-job training for the workers. Furthermore, the system provides an operational platform with augmented intelligence for the monitoring phase. Through a multi-sensorial network installed at the buildings, the system collects data related to the building performance, thus the Renovation Manager can compare the actual and the designed performance. In order to exchange the knowledge, the information, and the solutions of the system, RINNO introduces the Marketplace and Social Collaboration Platform. In that way, all the participants, including workers, engineers, tenants, as well as investors can exchange their experiences and their practices and provide each other assistance at all renovation phases. Finally, RINNO framework, during the whole lifecycle of the renovation process, utilizes the Renovation Workflow and Transactions Manager to optimize the supervision and the management of the project, and to ensure the speed up and the transparency of the transactions. The solutions developed by RINNO will be demonstrated at four large scale pilot sites covering different EU climatic zones and markets in France, Denmark, Greece, and Poland.

1.3 Interaction with other Tasks and Work Packages

Figure 1 describes the interaction between the Tasks, the Work Packages, and the architecture documentation. Task 1.1, Task 1.3, and Task 1.4 feed the architecture with inputs. Moreover, the outcomes of the present Task (T1.5), will provide valuable information to the other technical Work Packages of the project. More particularly, Task 1.1 specifies the stakeholder's requirements and the market needs, which are considered for the definition of the project architecture. Accordingly, Task 1.3 brings as input the stakeholder's requirements in terms of buildings renovation expectations from Task 1.1 and identifies the use case renovation scenarios, which define how the RINNO framework will be tested in pilots. The information flow of RINNO components is also defined utilizing information from both T1.3 and T1.5. It is worth to mention that Task 1.3 is developed in parallel with Task 1.1. The outputs of Task 1.3 will help the formation of the architecture and define the connection between the use cases and platform modules. The connection of the use-cases will be provided in the next version of the deliverable (namely deliverable D1.9 at M24).
The documentation of the RINNO architecture of Task 1.5 is based on:

- The requirements of stakeholders and market needs of Task 1.1.
- The use cases scenarios of Task 1.3.

Finally, the formation of the RINNO architecture will feed all technical and demonstration Work Packages, that is WP2, WP3, WP4, WP5, and WP6.

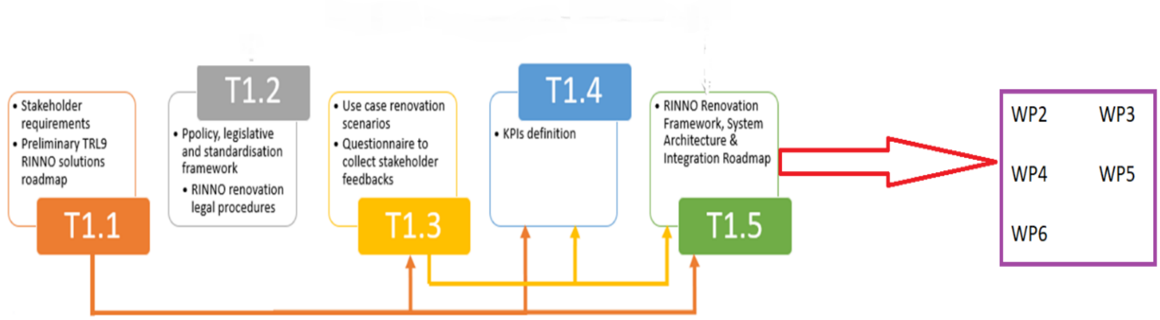

Figure 1 Interaction with other Tasks and Work Packages

2. Architecture Design Approach & Methodology

This chapter defines the approach and the methodology followed for designing the architecture. It is reminded that the present document constitutes the first iteration, and the next iterations will be used to update the previous versions of the architecture.

The designing phase of the architecture is divided into three phases: technology exploration, bottom-up and top-down.

2.1 Technology Exploration

The purpose of this phase is to explore the appropriate technologies that are suitable to RINNO and use these results as feedback for the development of the architecture. Specifically, other research projects that are relevant to RINNO are analysed. Moreover, essential architectural features are identified that should be considered. The next versions of the deliverable will provide an overview of the selected relevant projects with information about them and their role in the RINNO project.

2.2 Bottom-up Process

A set of technologies, components, modules, and sub-modules are under development by the individual partners of the RINNO project. The aim of this design phase is to gather and categorize the above-mentioned technologies. In that way, the knowledge and the experience of the partners is utilized by the platform as best as possible. Accordingly, the collection of the components can point out some gaps in the architecture that will be useful for the completion of the project.

Firstly, a template has been introduced to gather all the components. The following table contains the full list of main components brought by individual partners and a brief definition of all of them, along with the modules, the sub-modules, and the background technologies.

RINNO's framework comprises of 8 main components.

Table 1 List of Components

Main component	Module	Sub-module	Name of Background Technology	Responsible partner
RINNO Renovation Repository (RRR)	Modular Building Envelope Solutions	N/A	1) Bio-based double layer panels 2) Bio-based pipes and sheets 3) Isocell Cellulose Insulation 4) Thermochromic Glass	K-FLEX

Main component	Module	Sub-module	Name of Background Technology	Responsible partner
	RES Harvesting Solutions	N/A	1) Building integrated photovoltaic glass	GREENSTRUCT
	Storage Solutions	N/A	1) De-centralized domestic hot water preparation	PINK
	Multi-functional Hybrid Retrofitting Solutions	N/A	1) Climate Cover PV -Roof and -Facade solutions 2) MicroVent sustainable Ventilation system 3) K-BOX bio-based insulating system for parts of energy systems	EKOLAB
Middleware Infrastructure	IoT Sensorial Network & Control System	Automation systems	N/A	MOTIVIAN
		Sensors & actuators	N/A	MOTIVIAN
		Energy monitoring devices	N/A	MOTIVIAN
		IoT Device Managers	N/A	MOTIVIAN
	Common Information Translator (CIT)	Common Information Model (CIM) - BIM models (icf)	N/A	CERTH
	Middleware	Middleware engine	N/A	MOTIVIAN
RINNO Planning & Design Assistant (RPDA)	Renovation Modelling	Building Capturing & Mapping	COCKPIT platform for automated progress, quality & security control by drones	BOUYGUES
		Digital Twin	Renovation Digital-Twin	VTT
	Renovation Simulation & Assessment toolbox	Energy Assessment tool	1) INTEMA 2) Energy Performance Toolkit	CERTH
		Environmental, Cost and Social Assessment tool	LCA, LCC and S-LCA assessment toolkits	CIRCE
		Techno-economical assessment tool	Sustainable and cost-effective renovation evaluation toolkit	UNN
	Renovation Optimizer & Planner	Renovation Plan Generation tool	Dynamic decision-making toolkit	CERTH
		Renovation Scenarios Evaluation tool	Dynamic decision-making toolkit	CERTH

Main component	Module	Sub-module	Name of Background Technology	Responsible partner
RINNO Retrofitting Manager (RRM)	Process Industrialization	Recommendation Engine	On-site & Off-site assembling of prefab solutions by Cobots/Robots - Construction 4.0 Suite	BOUYGUES
		"Cockpit"	COCKPIT platform for automated progress, quality & security control by drones - Construction 4.0 Suite	BOUYGUES
		"3D printing"	3D-printing - Construction 4.0 Suite	BOUYGUES
	Process Optimization	Process Optimization tool	VIA-PROCESS Business Process Management - BPM	BOUYGUES
		"e-logistics"	E-LOGISTICS platform for optimized logistics	BOUYGUES
	On-the-Job AR Environment	AR Assistance tool	AR/VR suite – AR/VR enabled training and assistance	CERTH
		AR Training tool	AR/VR suite – AR/VR enabled training and assistance	CERTH
	RRM Engine	RRM engine	SCB (Smart Connected Buildings)	UNN
Building Lifecycle Renovation Manager (BLRM)	Intelligent Renovation Assistant	Renovation Validation and Benchmarking tool	N/A	CERTH
		Building Renovation Passports (BRPs)	N/A	EKOLAB
		Renovation Roadmap tool	N/A	EKOLAB
		Logbook tool	N/A	EKOLAB
Renovation Workflow & Transactions Manager (RWTM)	Renovation workflow tool	N/A	1) DPoW & xbimXplorer to be adapted into DRIP 2) VIA PROCESS	UNN
	Transaction manager toolkit	N/A	Smart Contracts for Multi-stakeholder Transaction Automation	CERTH
RINNO Operational Interface with Augmented Intelligence	RINNO Marketplace & Collaboration Platform (RMCP)	RINNO Marketplace	N/A	CERTH
		RINNO Collaboration Platform	Social Collaboration-	CERTH

Main component	Module	Sub-module	Name of Background Technology	Responsible partner
			Knowledge Sharing platform	
	Building Monitoring System (IoT Platform)	N/A	1) mSense tool for IoT management 2) Building Monitoring System	MOTIVIAN
	Central Dashboard	Building Performance Toolkit & Dashboard	1) Building Performance Evaluation toolkit 2) SCB (Smart Connected Buildings)	CERTH
		AR/VR UI	AR/VR suite – AR/VR enabled training and assistance	CERTH

It is worth mentioning that the components are grouped in three layers (physical, services, interaction layer) according to their nature and their functional characteristics as shown in Figure 2. The overall functional architecture is presented in the next chapter.

2.3 Top-Down Process

This phase is based on each component's functionalities and interaction between them. Accordingly, we utilize the use cases and construct sequence diagrams with the help of already defined components. This leads us to stress the services and features each component provides and design the interactions between them. Top-down process also describes how the other task will provide useful feedback to the development of the architecture as described in section 1.3. The use of this approach and the inspection of the functionalities that have been provided will also improve the high-level components APIs and clarify their role. Due to COVID-19 restrictions at the pilot sites, this process will be followed with more details at the two next versions of the architecture.

2.4 Documentation of the Architecture

The designing approach of the architecture follows the standard IEEE 1471 "Recommended Practice for Architectural Description for Software-Intensive Systems"[2]. This procedure is suitable for the architectural description of software intensive systems. This technique defines a set of patterns, rules, and templates on how to construct a type of view. Those viewpoints are described with UML diagrams. Within this document, the first version of architecture is presented through three main viewpoints (functional, deployment, information). Below a short

[2] IEEE Standard 1471-2000 (2000), IEEE Recommended Practice for Architectural Description of Software-Intensive Systems

description of each view is presented.

- Functional viewpoint (Chapter 3.): This view of a system describes its functional structure, including the key components, their features, and the interactions between them. Overall, it shows how a system will perform the functions required.
- Deployment viewpoint (Chapter 4.): This viewpoint describes how and where the system will be deployed. It also provides the dependencies between software and hardware components (e.g., hardware requirements, physical restraints).
- Information viewpoint (Chapter 5): This viewpoint describes the information flow and the data model. The information viewpoint also defines how the system saves, manages, and distribute information.

3. Functional View

In the current chapter, the overall functional architecture of the RINNO framework is presented along with a short description of its main components, modules, and sub-modules along with their functionalities and interactions.

3.1 RINNO Functional Architecture

The overall functional viewpoint of architecture is depicted in the figure below.

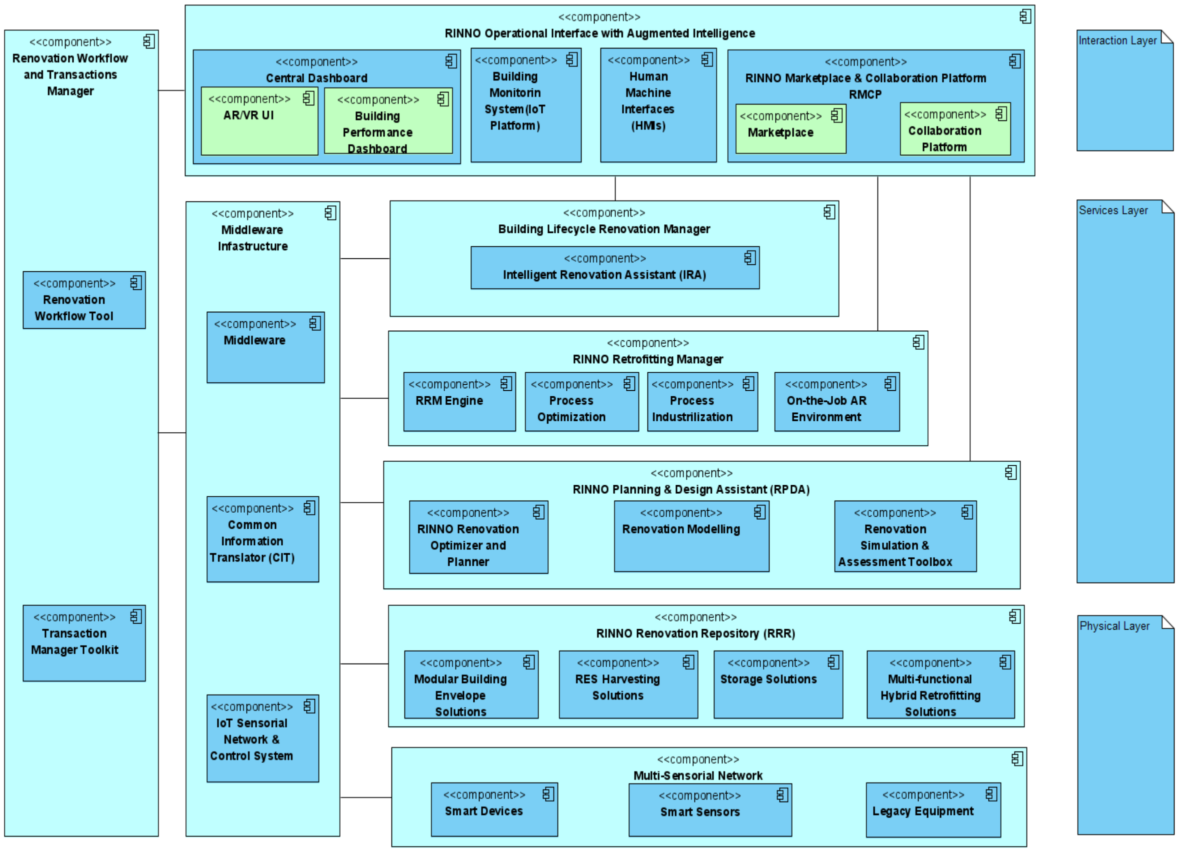

Figure 2 Overall Functional View

3.2 Overview of the main components, modules, and sub-modules

This section presents the key components, modules, and sub-modules of the RINNO platform and their main functionalities, and interactions.

3.2.1 RINNO Operational Interface with Augmented Intelligence

3.2.1.1 Social Collaboration Platform

This sub-module is part of RINNO Operational Interface with Augmented Intelligence component. It creates a knowledge base that will be used for better control and coordination of the renovation workflow and real time training of workers ("on-the-job" assistance). Communication among workers, managers, engineers and building owners will be available through an application (also in the form of a Mobile App). In addition, best practices for the renovation process and best practices and suggestions for energy efficiency for tenants will be provided.

Third parties will have the opportunity to include their technologies, ideas and best practices through this platform that will feed the knowledge base.

Finally, events and social networking will be supported for a better-connected work environment.

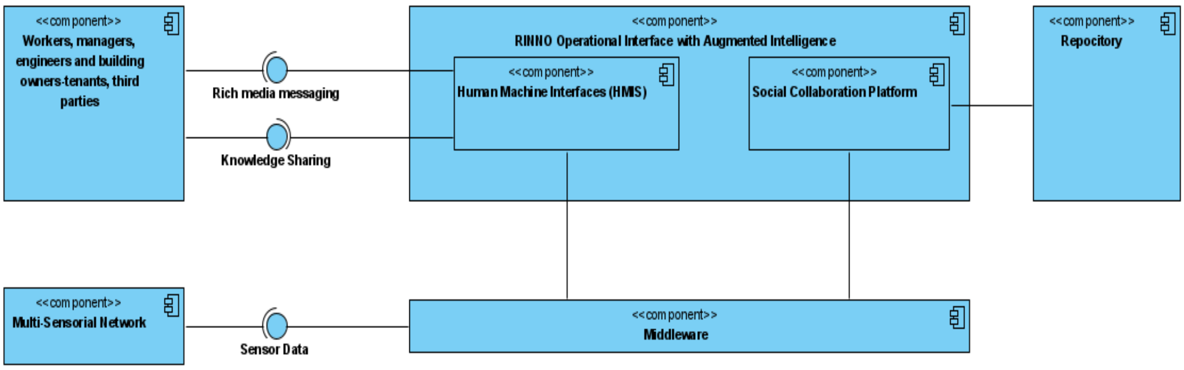

Figure 3 Social Collaboration platform's Component Diagram

The following tables explains in detail the main interfaces and their interconnection with the other components.

Table 2 Social Collaboration Platform - inputs

Social Collaboration Platform	Input Description
Rich media messaging	Information, knowledge, and experiences are exchanged (through the platform or through a Mobile App) among workers, managers, engineers and building owners. Ideas, technologies, and best practices, from third parties are also transferred data.
On-Site Information	Sharing information on-site, during the renovation activities
Information during real-time training	Data collected from Smart phones and tablets (location-based services) and smart helmets (further

	information)

Table 3 Social Collaboration Platform - outputs

Social Collaboration Platform	**Output Description**
Social Collaboration-Knowledge Sharing platform	Communication among workers, managers, engineers and building owners is available. Tenants are supported with best practices and suggestions for energy efficiency. Also, best practices in renovation activities are provided.
Suggestions/ Solutions to support workers	Direct communication tools to assist workers in the planning, scheduling, coordination, and optimization of work effort as well as real time training, significantly supports the renovation effectiveness.

3.2.1.2 Marketplace

This sub-module is part of RINNO Operational Interface with Augmented Intelligence component, along with the Collaboration Platform they form the RINNO Marketplace and Social Collaboration Platform. RINNO Marketplace aims to capitalize the solutions from the RINNO Renovation Repository as well as RINNO ICT tools. Moreover, 3rd parties will crowd-populate the RRR, through the RINNO Marketplace, to optimize each renovation solution with the support of the RINNO Planning and Design Assistant and the RINNO Retrofitting Manager. In addition, the technical tools of the RINNO suite feeds the Marketplace with inputs. That way ensures that the RINNO Suite will not be outdated and will continuously provide updated optimized solutions and 3rd parties technologies to the RRR. The RRR will also be able to generate automatic databases of materials and renovation products (e.g. EPD, ELCD, etc.), allowing its configuration. The Marketplace sub-module continuously introduces 3rd party technologies through point-to-point protocols to the RRR and achieves the sales of not only RINNO, but also 3rd party technologies along with the ICT products that RINNO Suite provides.

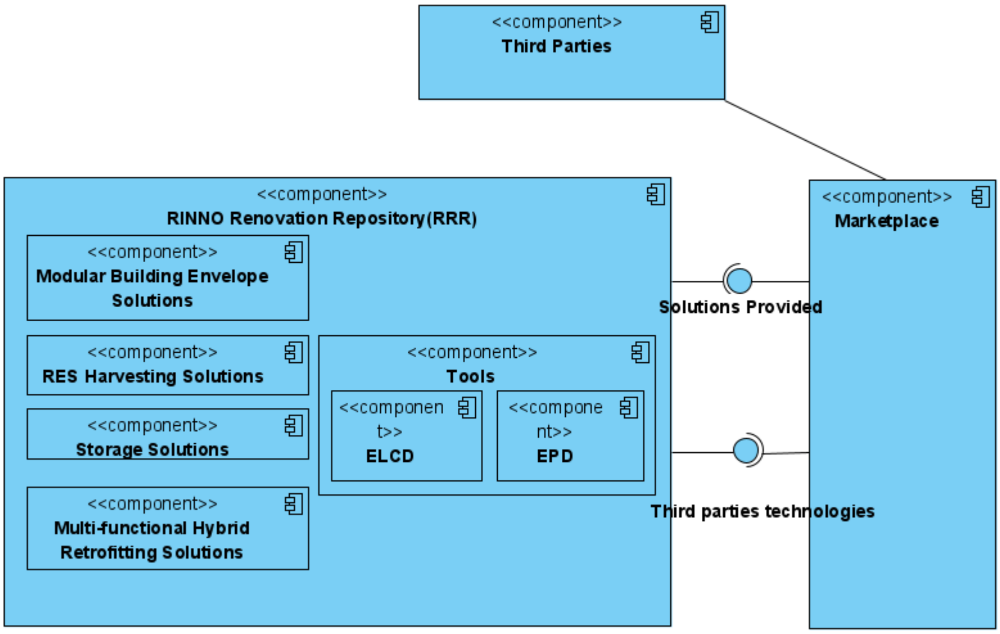

Figure 4 Marketplace Component Diagram

Table 4 Marketplace - inputs

Marketplace	Inputs Description
Solutions provided by the RINNO Renovation Repository	The solutions of the Repository include: • Envelope retrofitting solutions. • Energy systems (RES harvesting, hybrid & Storage Solutions) • Retrofitting process improvement techniques • Business Models.

Table 5 Marketplace - outputs

Marketplace	Output Description
Third parties' technologies	RINNO Renovation Repository will be crowd-populated through the Marketplace by third parties to facilitate its natural expansion and ensure that both novel and conventional solutions are included and can be used for optimising each renovation case.

3.2.1.3 Building Monitoring System (IoT Platform)

The Building Monitoring System (IoT platform) is a module of RINNO Operational Interface with Augmented Intelligence component. BMS connects in-use performance data with BIM context and provides usable advice to property owners and tenants. This module will take BIM models in the form of Industry Foundation Classes (IFC) and enables users to link sensors and other data, such as tenant profile data to spaces within buildings. BMS will relate to the IoT sensorial middleware to understand the behavioural profile of users. BMS will be able to monitor any IoT device. It can receive information from any kind of device installed in the buildings under any kind of protocol. Finally, depending on the type of IoT sensors installed, the IoT Platform can generate different functionalities about the renovation process (e.g. the monitoring of parameters, advancements…) and the operation of the building.

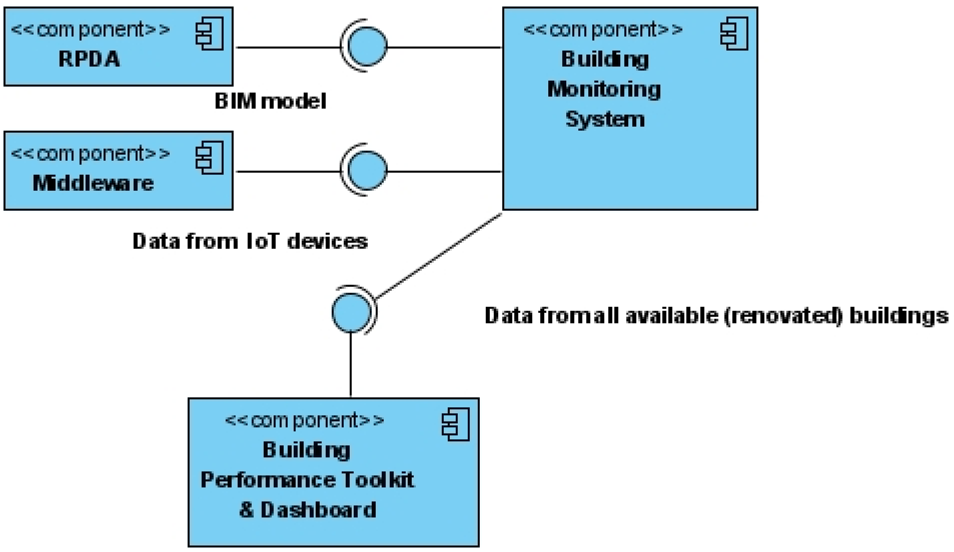

Figure 5 Building Monitoring System Component Diagram

Table 6 Building Monitoring System - inputs

Building Monitoring System	**Inputs Description**
BIM models	The Building Monitoring System gets a BIM model in the form of Industry Foundation Classes (IFC).
Data from IoT devices in the buildings	The Building Monitoring System gets information from any kind of device installed in the buildings (e.g. energy, environmental meters) under any kind of protocol (e.g. TCP/IP, Bluetooth, ZigBee, Z-Wave).

Table 7 Building Monitoring System - outputs

Building Monitoring System	Output Description
Data from all available (renovated) buildings during the phase of renovation and operation.	The Building Monitoring System can extract useful information such as e.g., short-term energy consumption predictions, data correlations, comparisons, reports.

3.2.1.4 Central Dashboard

3.2.1.4.1 Building Performance Toolkit & Dashboard

Building Performance Toolkit & Dashboard is a sub-module of RINNO Operational Interface with Augmented Intelligence. Along with AR/VR User Interface they form the Central Dashboard of Operational Interface. This toolkit will allow users to create personalized dashboards based on the information they are interested in. The dashboard will enable the facility manager and the occupants to monitor building operations and decide optimal strategies. Users will also be able to set up custom alerts in order to receive notifications under certain circumstances (e.g. humidity). This sub-module utilizes visual and data analytics techniques for the analysis of the data through a spatiotemporal analysis and correlations between building parameters and various KPIs at different domains (e.g. geometric, energy consumption, usage, etc.). The dashboard will be fed with data through the Building Monitoring System (i.e. IoT platform).

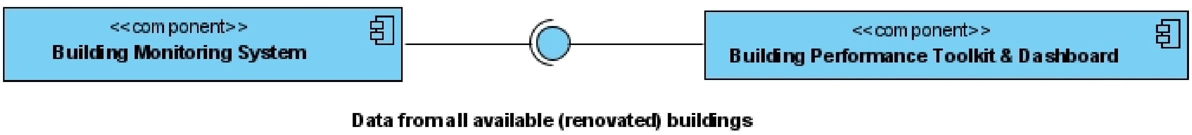

Figure 6 Building Performance Toolkit & Dashboard Components Diagram

Table 8 Building Performance Toolkit & Dashboard - inputs

Building Performance Toolkit & Dashboard	Input Description
Data from all available (renovated) buildings during the phase of renovation and operation.	Useful information such as e.g., short-term energy consumption predictions, data correlations, comparisons, reports.

3.2.1.4.2 AR/ VR User Interfaces (UIs)

This Section is referred to the User Interfaces (UIs), which will be delivered by the AR on-the-job training toolkit (Section 3.2.3.1).

3.2.2 RINNO Planning & Design Assistant (RPDA)

3.2.2.1 RINNO Renovation Optimizer and Planner

This module belongs to the RINNO Planning and Design Assistant component. The RINNO Renovation Optimizer and Planner will determine the optimum renovation scenario and the optimum sequence of interventions. The optimum scenario will be selected based on the results of the Energy Assessment tool (3.3.1), the Environmental, Cost and Social Assessment tool (3.3.2) and the Techno-economical assessment tool (3.3.3) and the use of appropriate KPIs defined in T1.4. The optimum sequence of interventions will be selected based on KPIs regarding retrofitting time, cost and disturbance of occupants and will aim at minimizing them.

The tool receives inputs from the simulations of the Energy Assessment tool, the Environmental, Cost and Social Assessment tool and the Techno-economical Assessment tool for all potential renovation scenarios (collectively the RINNO simulation and Assessment toolkit). The scenarios that are examined have been produced by considering the status of the building (the renovation modelling toolkit generating the scenarios receives real-time data from the multi-sensorial network through the middleware infrastructure). The evaluation of the scenarios will be conducted based on appropriate KPIs defined in T1.4.

The output of the Renovation Optimizer and Planner will be fed to the other components related to the construction and monitoring stage of the renovation, namely the RINNO Retrofitting Manager and the Building Lifecycle Renovation Manager through the Renovation Workflow and Transaction Manager.

This component success is interconnected with the interaction with multiple components as depicted in the schema below.

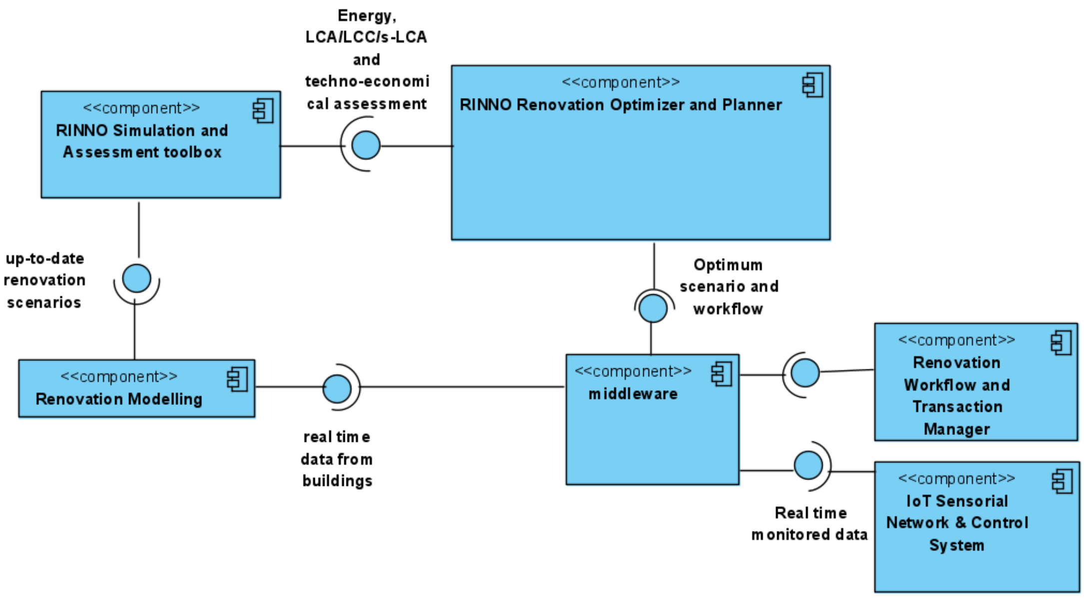

Figure 7 RINNO Renovation Optimizer and Planner Component Diagram

The following tables explain in detail the main interfaces, and their interconnection with the RINNO Renovation Optimizer and Planner component.

Table 9 RINNO Renovation Optimizer and Planner - inputs

Renovation Optimizer and Planner	**Inputs Description**
Scenarios assessment data	The RINNO Renovation Optimizer and Planner receives inputs from the RINNO Simulation and Assessment toolkit on the assessment of the proposed renovation scenarios in terms of • energy performance • environmental cost, and social impact • techno-economic performance. Renovations scenarios are then ranked based on their performance in these three assessment categories. The scenarios generated are based on the building's current condition. For this, the Renovation Modelling toolkit (BIM and Digital Twin) receives monitored data from the multi-sensorial network through the middleware infrastructure.

Table 10 RINNO Renovation Optimizer and Planner - outputs

Renovation Optimizer and Planner	**Outputs Description**
Selected Renovation scenario and sequence of interventions	All potential renovation scenarios will be ranked based on appropriate KPIs and for each building investigated the tool will identify the most suitable technologies and their integration. The planning of interventions will also consider suitable KPIs on retrofitting time, cost, and disturbance. The RINNO Renovation Optimizer and Planner will select the optimum renovation scenario for each building as well as the optimum sequence of interventions. This will then be fed through the Renovation Workflow and Transaction Manager and used in WP4 for the planning of the construction process, in WP5 for the validation of the renovation process and will be demonstrated in WP6.

3.2.2.2 Renovation Simulation & Assessment tool

3.2.2.2.1 Energy Assessment

This submodule belongs to the RINNO Simulation and Assessment toolbox module which in turn belongs to the RINNO Planning and Design Assistant component. The Energy Assessment tool (subtask 3.3.1) will assess the energy performance of the various renovation scenarios considering the specifications of the building envelope, the various thermal zones, the building systems, RES production systems, weather data and user behaviour. The dynamic energy demand (thermal and electrical) of the buildings will be investigated along with the RES production, potential and own-use utilization through assessing possible RES harvesting synergies combined with storage solutions. The tool will also offer forecasting functionalities of key operational parameters (power production, demand etc.).

Finally, it is envisaged that the tool will additionally have responsive capabilities offering recommendations to the users and will support control and actuations functionalities. This is a development that goes beyond the requirements of the RINNO project and if this goal is realized it will offer the potential for more energy efficient operation of the building by minimizing energy consumptions and losses and optimizing RES own use.

The Energy Assessment tool receives input on the building geometry, the thermophysical properties of the building elements as well as the various combinations of building and RES systems for all potential renovation scenarios through the Renovation Modelling Toolkit (BIM, Digital Twin) (T3.1, T3.2). Furthermore, monitored data (near real time) on the building performance, will be directly passed to Energy assessment tool via the multi-sensorial network and through the middleware. Additional input for the technologies will be received from the RINNO Renovation Repository component (WP2).

The output will be used by the RINNO Renovation Optimizer and Planner (T3.4) to determine the optimum renovation scenario. In addition, the output of the Energy Assessment tool will partly feed the Environmental, Cost and Social Assessment tool (subtask 3.3.1). Finally, the tool will provide recommendations to the users of the building (occupants, building managers) and carry control and actuation tasks on building elements through the Middleware Infrastructure (IoT Sensorial Network and Control System) and the Renovation Workflow and Transaction Manager.

This component success is interconnected with the interaction with multiple components as depicted in the schema below.

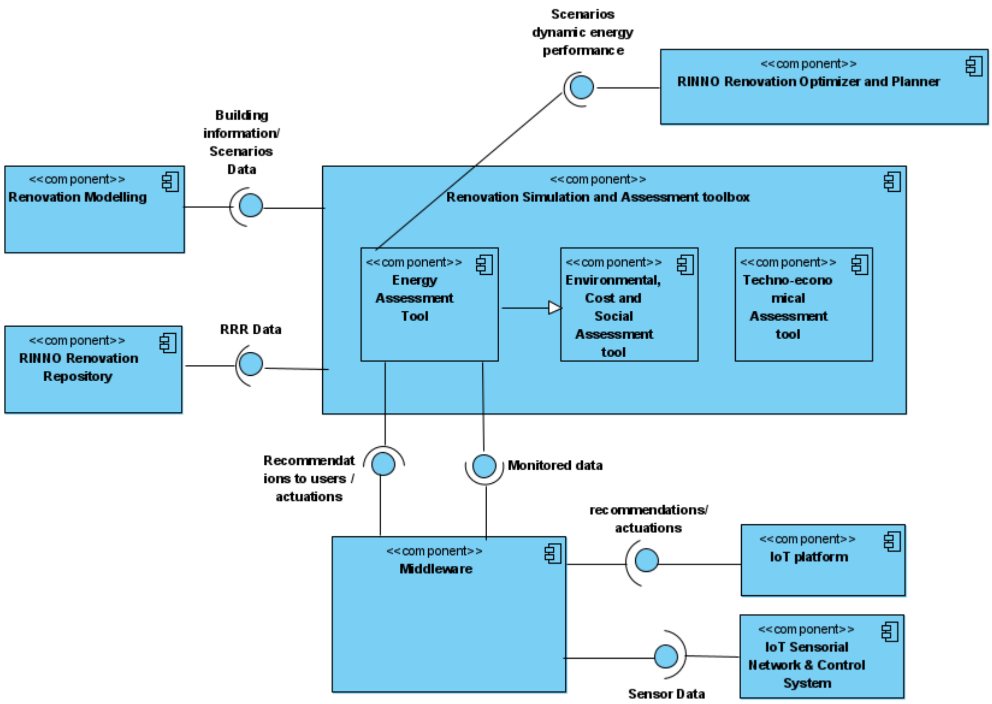

Figure 8 Energy Assessment tool Component Diagram

The following table explains in detail the main interfaces, and their interconnection with the Energy Assessment tool component.

Table 11 Energy Assessment tool - inputs

Energy Assessment tool	Inputs Description
Building information from the Renovation Modelling toolkit (BIM, Digital Twin)	The Energy Assessment tool will receive inputs on the building geometry, the thermophysical properties of the building elements as well as the existing building systems and RES systems that produce thermal or electrical energy from the Renovation modelling toolkit so that the dynamic energy performance (demand and production) of the existing building will be assessed. Furthermore, the proposed renovation scenarios, considering the various technological solutions and their integrations and synergies, will also be provided to determine their energy performance
Information and data on the technologies used from the RINNO Renovation Repository (RRR)	The specifications of the technologies used on a renovation scenario will be taken by the RINNO Renovation Repository. These specifications (such as power, capacity factor, maximum and minimal voltage and current etc. for an electricity production system) are required for the modelling the technologies and their integration on the buildings as well as the energy assessment of the various scenarios.
Building Monitored Data	The tool will receive monitored data from the building to have the up-to-date information on the energy performance. The tool will then act as a decision support engine providing recommendations to the users and supporting actuations for the most energy efficient operation of the building.

Table 12 Energy Assessment tool - component outputs

Energy Assessment tool	Output Description
Energy performance data to the RINNO Optimizer and Planner	Results of the analysis on the energy assessment of the various scenarios will be fed to the RINNO Renovation Optimizer and Planner to rank them in terms of energy performance based on appropriate KPIs.
Operational data for the Environmental, Cost and Social assessment tool	Specific output data (such as the forecasted power production for RES systems etc.) will be fed to the Environmental, Cost and Social assessment tool (3.3.2) to conduct the LCA/LCC/s-LCA analysis of the renovation scenarios.
Recommendations/actuations on building use	The tool will provide recommendations to the users and support actuations that will lead to the minimization of energy consumption and losses and increase RES self-consumption.

3.2.2.2.2 Techno-economical Assessment

This submodule is part of the RINNO Planning & Design Assistant (RPDA) component. The main aim of techno-economical assessment (TEA) tool is to evaluate, for each renovation scenarios considered, the impact of the works in terms of user disturbance and waste production. With reference to waste production, the logistic implications (transport and site) will also be considered.

Specifically, the TEA tool consists of two different parts:

- Activities configuration module: to identify the worksite scenarios that minimize time, costs, and disturbance to users.
- Waste Management Module: it allows to identify quantities and logistical needs for different waste categories according to the types of waste produced.

The tool receives inputs from the building geometry, construction phases, materials, separation degree of materials of both the existing building and the related refurbishment scenarios to be assessed, through the Renovation Modelling Toolkit (BIM, Digital Twin) (T3.1, T3.2). Additional inputs for the technologies will be received from the RINNO Renovation Repository (WP2) about product innovations.

The output will be fed into the RINNO Renovation Optimizer and Planner (T3.4) in order to determine the optimum renovation scenario. In detail, the TEA tool will calculate the impact on different users in terms of interruption of services, indoor environmental quality (acoustic, light, air quality), accessibility to areas and promiscuity with workers.

The interconnections and the interfaces of the submodule with other submodules are depicted in figure below.

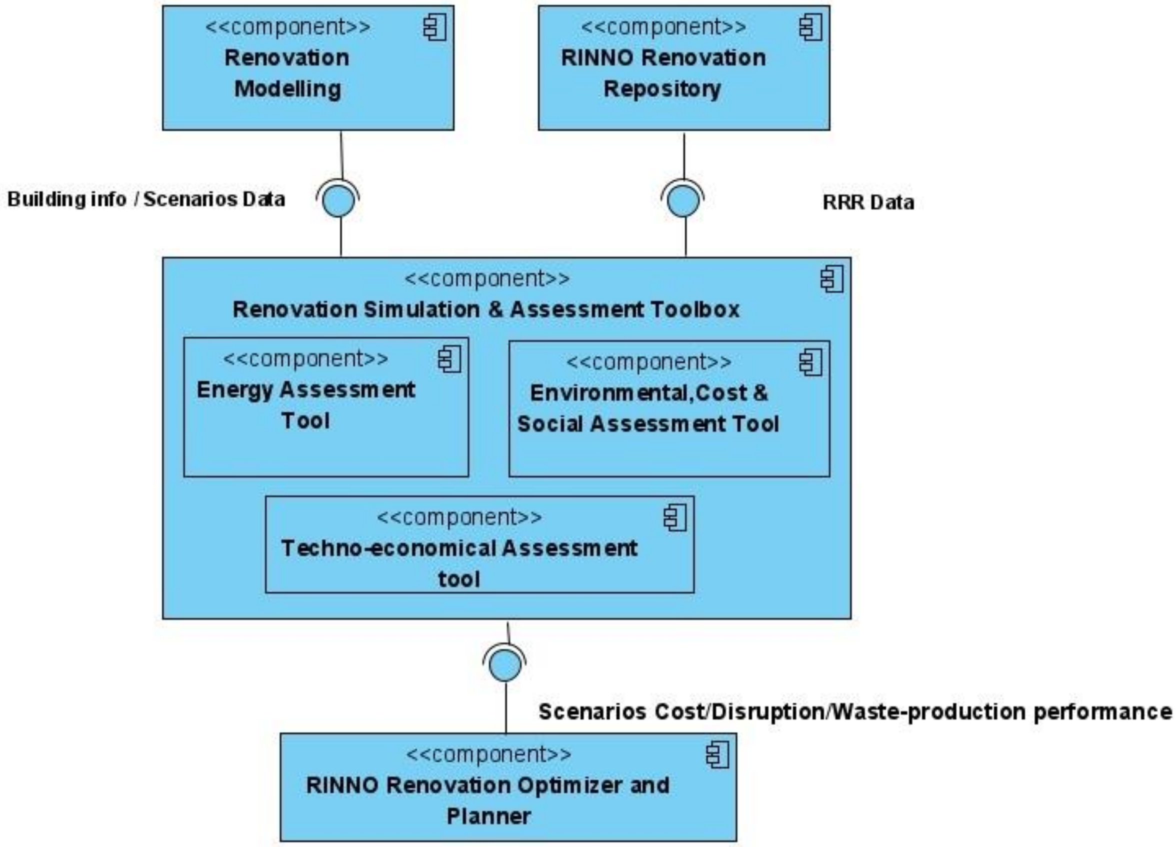

Figure 9 Techno-economical Assessment Tool Component Diagram

Table 13 Techno-economical Assessment Tool - inputs

Techno-economical Assessment Tool	**Input Description**
Building information from the Renovation Modelling toolkit (BIM, Digital Twin)	The Techno-economical Assessment tool will receive input on the building geometry, construction phases, materials, separation degree of materials of both the existing building and the related refurbishment scenarios to be assessed.
RINNO Renovation Repository (RRR)	Specifications of the technologies used on a renovation scenario will be taken by the RINNO Renovation Repository. Data gathered from the RRR through the middleware will be used in BIM format. These specifications are required to assess cost and impact in terms of user disruption resulting from their integration on the buildings.

Table 14 Techno-economical Assessment Tool - outputs

Techno-economical Assessment Tool	**Output Description**

Environmental, Cost and Social performance data to the RINNO Optimiser and Planner	Renovation scenarios will be assessed in terms of user disruption, waste generation and relevant costs in terms of renovation work progress. These results will be than fed to the RINNO Renovation Optimizer and Planner to rank them based on appropriate priorities.

3.2.2.2.3 Environmental, Cost and Social Assessment

This sub-module belongs to the RINNO Simulation and Assessment toolbox module which in turn belongs to the RINNO Planning and Design Assistant component. The Environmental, Cost and Social Assessment tool will conduct the analysis of the proposed renovation scenarios of each demo site regarding:

- The Lifecycle Assessment of the renovation scenarios, where the evaluation of parameters such as
  a) embodied energy of the renovation components,
  b) accumulated primary energy demand,
  c) CO_2 emissions per kWh produced,
  d) energy and CO_2 payback time for the renovation components,
  e) Lifetime GHG emissions
  f) avoided GHG emissions achieved will take place.
- The Lifecycle Cost assessment of the renovation scenarios where the direct, indirect, internal, and external costs incurred will be evaluated for all stages during a project's lifetime (capital, operation and maintenance and end-of-life costs).
- The assessment of social life cycle assessment (S-LCA) aspects concerning the residents' welfare during the building renovation process.

The evaluation of the renovation scenarios will be conducted based on the KPIs defined in T1.4. The tool receives input from the Energy Assessment tool regarding some operational parameters of the renovation scenarios. Additional input for the technologies will be received from the RINNO Renovation Repository component (WP2).

The output will be fed into the RINNO Renovation Optimizer and Planner (T3.4) to determine the optimum renovation scenario. In addition, the output of the LCC assessment will assist the business modelling tasks in WP7 that will be customer focused guided by circular renovation principles.

This component success is interconnected with the interaction with multiple components as depicted in the schema below.

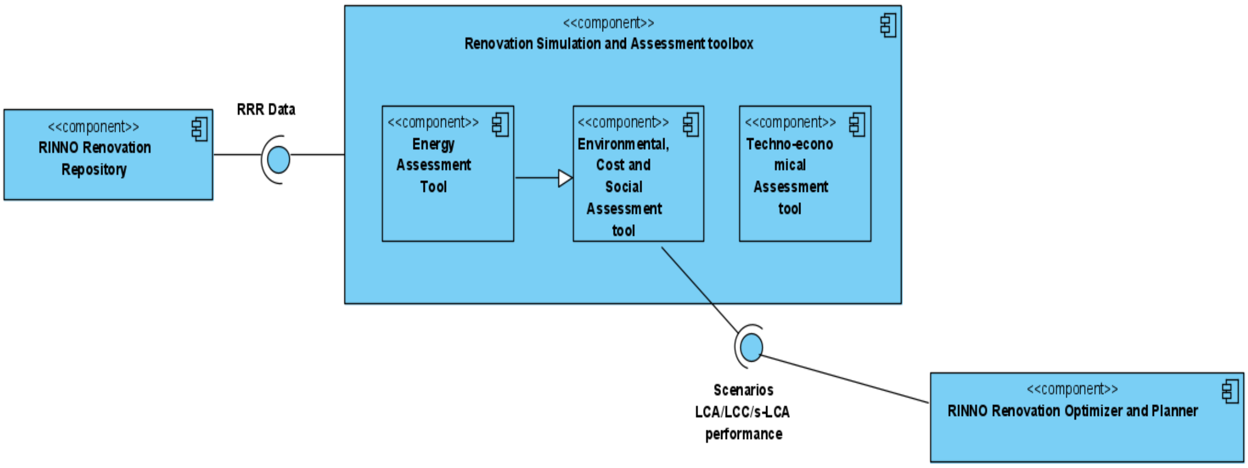

Figure 10 Environmental, Cost and Social Assessment tool Component Diagram

The following table explains in detail the main interfaces, and their interconnection with the Environmental, Cost and Social Assessment tool component.

Table 15 Environmental, Cost and Social Assessment tool - inputs

Environmental, Cost and Social Assessment tool	Inputs Description
Operational data from the Energy Assessment tool	The Environmental, Cost and Social Assessment tool will receive inputs on certain operational parameters (such as capacity and energy production of RES systems, building energy consumption etc.) from the output of the Energy Assessment tool. This input is required to estimate the environmental and social impact as well as the cost during the operational phase of the renovated building.
RINNO Renovation Repository (RRR)	Specifications of the technologies used on a renovation scenario will be taken by the RINNO Renovation Repository. Data gathered from the RRR through the middleware will be used in BIM format. These specifications are required for determining the environmental impact and cost of the technologies and their integration on the buildings throughout the lifecycle of the building.

Table 16 Environmental, Cost and Social Assessment tool- outputs

Environmental, Cost and Social Assessment tool	Output Description
Environmental, Cost and Social performance data to the RINNO Optimizer and Planner	Results of the analysis on the environmental, cost, and social assessment of the various scenarios will be fed to the RINNO Renovation Optimizer and Planner to rank them based on

	appropriate KPIs.

3.2.2.3 Renovation Modelling

3.2.2.3.1 Building Capturing and Mapping

This sub-module belongs to the RINNO Planning and Design Assistant component. RINNO will capture and align the basic existing geometrical information of the building features under renovation, while considering any required structural repairs, leading to the necessary BIM. The building-as-is capturing will be firstly achieved via a questionnaire, which will be circulated to the demo sites. Then both conventional (accelerometers, gyroscopes, GPS), and very innovative devices (Ars scanners and drones) will be also deployed for the building-as-is capturing and reconstructing the 3D geometry of the existing buildings and model them in BIM.

On top of these devices, RINNO will deliver a multiplatform software technology allowing:

- immersive environment for additive/corrective scanning/reconstructing of existing building data with design drafting/review and BoQ (Bill of Quantities) functionalities,
- the sharing of building data among other stakeholders (located locally or remotely).

These conventional and innovative devices will gather onsite data by creating a cloud of points that will form the building shape. On the other hand, some algorithms will be developed to map these points together and create a BIM model. This creation will allow us to differentiate between the main components of the envelope: windows, doors, roof, concrete, etc.

The output of this task will be an IFC BIM model. The result will be connected to the Renovation Digital Twin and the Renovation Assessment Toolbox.

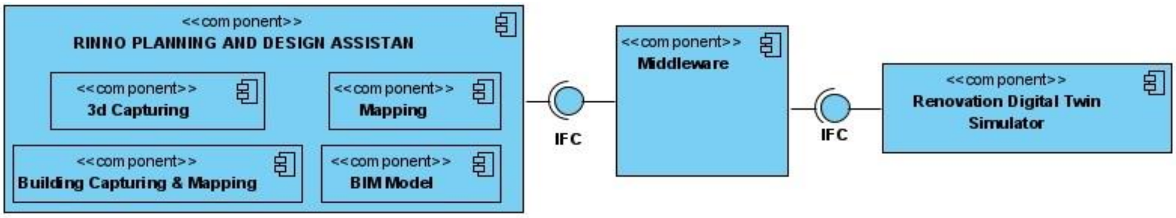

Figure 11 Building Capturing and Mapping Component Diagram

The following table explains in detail the main interfaces, and their interconnection with this component.

Table 17 Building Capturing and Mapping - inputs

Building Capturing and Mapping	Inputs Description
Cloud of points	Drones are often used to collect a series of RGB images which can be later processed on a computer vision algorithm platform such as on AgiSoft Photoscan, Pix4D or DroneDeploy to create RGB point clouds from where

	distances and volumetric estimations can be made.

Table 18 Building Capturing and Mapping - outputs

On-the-Job AR Environment	Output Description
IFC BIM Model	The Industry Foundation Classes (IFC) data model is intended to describe architectural, building and construction industry data. It is a platform neutral, open file format specification that is not controlled by a single vendor or group of vendors. It is an object-based file format with a data model developed by building SMART (formerly the International Alliance for Interoperability, IAI) to facilitate interoperability in the architecture, engineering, and construction (AEC) industry, and is a commonly used collaboration format in Building information modelling (BIM) based projects.

3.2.2.3.2 Digital-Twin

Renovation buildings Digital-Twin sub module subject to energy efficient renovation plan, to make the renovation offer more attractive and less time-consuming to all relevant stakeholders by assessing different renovation solutions with an automatized building modelling approach (Machine Learning based). Its primary advantage over other approaches lies on being simpler in terms of formulation and application compared to conventional modelling approaches, without the requirement of dedicated experts' involvement.

The VTT Digital-Twin model is created based on a mix of existing mathematical & physical model of the building and info pulled from extensive databases, where either aggregated data (e.g., energy bills) or historical data (delivered by IoT middleware) are stored. The Digital-Twin building model is trained based on a) either hourly measurement data (indoor temperature, energy consumption of single consumption points – heating/cooling elements and/or electrical equipment (ventilation fans, home/office appliances) or b) building consumption point, building automation data, IoT sensors data and weather data) and, if available, geometry of the building (from CAD data file) and thermal properties of building envelope elements.

This module success is interconnected with the interaction with multiple components as depicted in the scheme below.

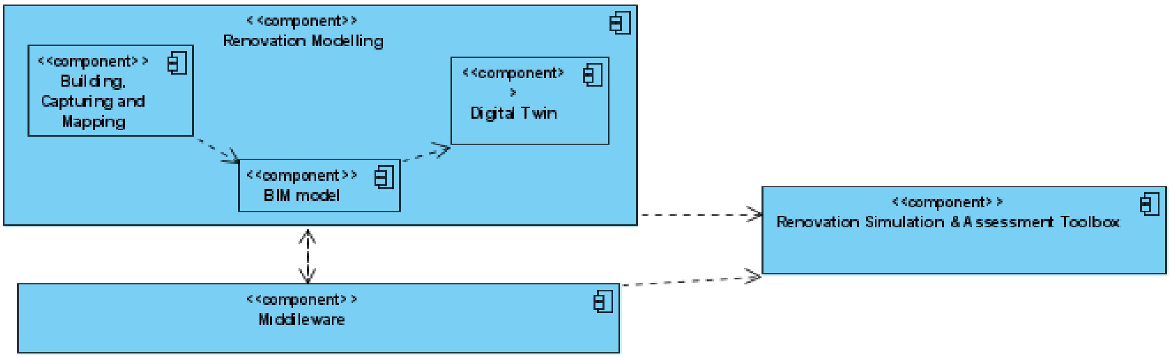

Figure 12 Renovation Digital-Twin Component Diagram

This tool is part of the RINNO Renovation Modelling module. The following table explains in detail the main interfaces, and their interconnection with Renovation Digital-Twin component.

Table 19 Renovation Digital-Twin - inputs

Renovation Digital-Twin -tool	**Inputs Description**
Building sensor information	• IoT sensor data • BEMS data • Weather data
Basic building information	• Country • Building type • Construction year • Weather data • Cooling set point • Heating set point. • Space heating/cooling type • Conditioned floor area • Number of floors, • Floor height, • Number of residents
Renovation options	Measures to improve: • the building airtightness. • the thermal insulation of the windows/outside walls/base floor/roof. • the solar shading of the windows.

Renovation Digital-Twin -tool	Inputs Description
	• the mechanical ventilation system by adding heat recovery for the ventilation system. • the energy efficiency of the hot water system. • energy efficiency and/or CO_2-emission efficiency of the heating/cooling system. • the space heating efficiency by adding an auxiliary space heating system.

Table 20 Renovation Digital-Twin -outputs

Renovation Digital-Twin -tool	Output Description
Space heating and hot water	(Before, After and Savings information)
Appliance electricity	(Before, After and Savings information)
Space cooling	(Before, After and Savings information)
Carbon footprint	(Before, After and Savings information)
Energy cost	(Before, After and Savings information)
Investment cost	(Before, After and Savings information)
Payback time	(Before, After and Savings information)

3.2.3 RINNO Retrofitting Manager (RRM)

3.2.3.1 On-the-Job AR Environment

This module belongs to the RINNO Retrofitting Manager. On-the-Job AR Environment is responsible for the design of services and interfaces, as well as their integration to the workplace, to support workers within an attractive ambient environment. The target stakeholders of this module are:

- Support employees in carrying out specific operating procedures.
- Support employees by providing access to advanced information and content.

Services are provided for the support of all procedures required by the project (training and assembly) and in any procedure that this information can add value (first group of target stakeholders). An AR Assistance tool & AR Training sub-module has been developed targeting the training of employees (second group of target stakeholders) “off-line” with predefined scenarios, and/or on-site with AR techniques. An approach both "on the job" (based on Augmented Reality capabilities), and in a "simulated environment" (totally based on Virtual Reality) is implemented in order to guide users (novice workers) in their activity by presenting the step-by-step procedures interactively, by providing guidance on tools, materials, and components involved and their use. These tools are enhanced to support functionalities such as image-video sharing and VoIP. Useful information is provided to decrease:

- the construction site-work time as well as the training time of novice workers.

- the errors and faults during the renovation processes.
- any delays, since potential problems could be solved on-site at the time they arise.

Useful data are gathered from the multi-sensorial network to create a knowledge base. Data are retrieved from AR/VRs scanners, drones, robots, cobots, photogrammeters and allow to determine if a procedure visualized through these tools has been correctly implemented. This information is useful as training material as well for workers on real site conditions. Another source of information is from smart devices and HMIs such as smart phones, tablets and smart helmets that provide location-based data and constitute communication means available among workers.

A variety of services are available through the AR Assistance tool & Training tool. Such services include:

- exchange of information and communication
- AR-assisted architectural narratives
- geolocating BIM data on the construction site
- work-instruction delivery
- 4D phasing of construction work sites
- training platform for maintenance and repair
- AR for facility management
- object tracking
- target recognition (ML techniques).

The Middleware infrastructure provides interoperability among sensors and devices with different protocols, data necessary for the On-the-Job AR Environment component. It allows any kind of information to be transferred to the end users.

The presentation of the information transferred is achieved through innovative HMIs that belong to the Interactive Layer and it can be considered strictly integrated component of the On-the-Job AR Environment component. The services are designed so that through visualization tools of the available HMIs, information, and content from pre-packaged scenarios as well as generated data at runtime (based on information coming from the multisensorial network) can be distributed directly to the HMIs. These HMIs are in the form of smart devices such as smart phones and tablets as well as smart helmets and provide guidance to the whole operation (showing for example where components should be installed and further information to modules installation).

This component success is interconnected with the interaction with multiple components as depicted in the schema below.

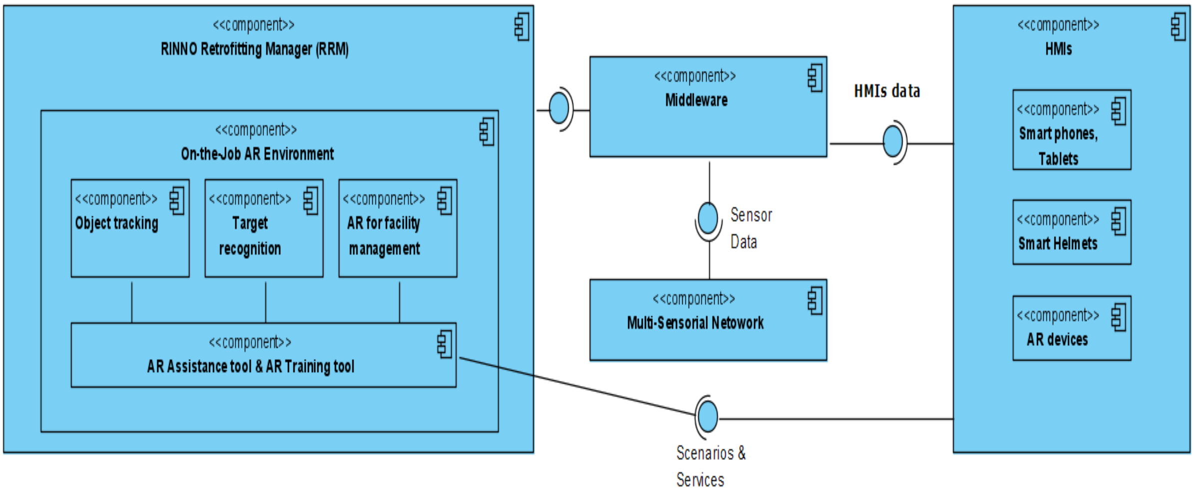

Figure 13 On-the-Job AR Environment Component Diagram

The following tables explains in detail the main interfaces, and their interconnection with the On-the-Job AR Environment component.

Table 21 On-the-Job AR Environment - inputs

On-the-Job AR Environment	Description
HMIs data	Through smart devices such as tablets and smart phones as well as smart helmets, workers provide information (location-based data and communication data in the form of sound, video, text, and AR content) so that the AR Assistance tool & AR Training tool can provide guidance and practical information for training purposes along with a variety of services.
Sensor Data	Through a plethora number of devices and sensors such as AR/VRs scanners, drones, robots, cobots and photogrammeters, the data gathered allow to determine if the renovation procedures are correctly implemented. This data from the training scenarios will also form a knowledgebase to be exploited for the training of inexperienced workers. This data must support the services provided by the AR Assistance tool and AR Training tool. Such data for example must include geolocating BIM Data of the construction site

Table 22 On-the-Job AR Environment - outputs

On-the-Job AR Environment	Description
Scenarios & Services	The AR Assistance tool & AR Training tool makes available a variety of services and training, with predefines scenarios directly to the HMIs. The services provided are exchange of information and communication, AR-assisted architectural narratives, geolocating BIM data on the construction site, work-instruction delivery, 4D phasing of construction work sites,

	training platform for maintenance and repair, AR for facility management, object tracking, target recognition (ML techniques). For example, appropriate guidance during installation via AR interfaces – pointing to the exact location where a component shall be installed as well as alerts on health/safety issues in the form of sound, video, text, and AR content

3.2.3.2 RINNO Retrofitting Manager Engine (RRM Engine)

This module is part of the RINNO Retrofitting Manager, which integrates the following modules:

- The process Industrialization module
- The process optimization module
- The on-the-job AR Facilitating Environment module.

The RRM Engine should be able to help execute, analyse, monitor, and manage the renovation process, while it can also guide and even train the workforce on-site through the cloud.

Especially, it should:

- Make data accessible in real-time through a user-friendly interface with role-based authorization.
- Optimize the performance of works and the supply chain minimizing costs and saving space.
- Provide real-time reports on renovation progress to allow decision making.
- Notify stakeholders via email to remind submitting their data in a time.

This component will be developed based on the Smart Connected Buildings (SCB) platform made of multiple interconnected components as depicted in the following schema.

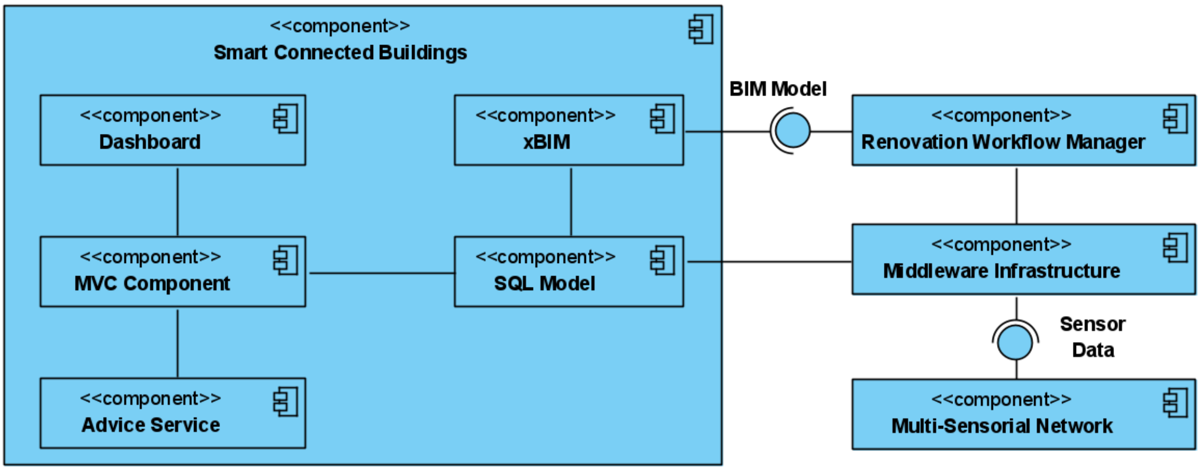

Figure 14 RINNO Retrofitting Manager Engine Component Diagram

The following table explains the main interfaces, and their interconnection with the RRM Engine component.

Table 23 RINNO Retrofitting Manager Engine - inputs

RINNO Retrofitting Manager Engine	Inputs Description
Sensor Data	Through the Middleware Infrastructure, deployed sensors (temperature, humidity, motion, light, power, gas, etc.) provide real-time data to be stored in the SQL Model (SCB database), then used for immediate visualization or informing users via alerts/advices after processing.
BIM Model	After being created by the RPDA component, the Renovation Workflow Manager provides the BIM model to be used by the SCB platform. An interface between the BIM model uploaded in IFC file format, and the SCB platform will be provided through an existing BIM Academy library xBim, providing easier access to the IFC file by creating a temporary, in memory database. Thus, easier extraction of the building, its floors, apartments and rooms so they can be stored in an SQL database.

Table 24 RINNO Retrofitting Manager Engine - outputs

RINNO Retrofitting Manager Engine	Output Description
Sensor Data	Through the Middleware Infrastructure, deployed sensors (temperature, humidity, motion, light, power, gas, etc.) provide real-time data to be stored in the SQL Model (SCB database), then used for immediate visualization or informing users via alerts/advices after processing.
BIM Model	After being created by the RPDA component, the Renovation Workflow Manager provides the BIM model to be used by the SCB platform. An interface between the BIM model uploaded in IFC file format, and the SCB platform will be provided through an existing BIM Academy library xBim, providing easier access to the IFC file by creating a temporary, in memory database. Thus, easier extraction of the building, its floors, apartments, and rooms so they can be stored in an SQL database.

3.2.3.3 Process Industrialization

The process industrialization (E-Cockpit) is sub-module that is part of RINNO Retrofitting Manager. It represents the global digitalization of all the site construction activities to provide relevant information on the “Production Monitoring”. This tool enables an objective, real time, permanent and effortless supervision of the site tasks.

The objective is to transmit synchronous information for reactivity actions and necessary adaptations to every type of events (ex: Delays on delivery, lack of manpower, bad weather, etc.).

In addition, the E-Cockpit gather productivity objective measurement information for management pertinent decision.

This permits resources savings by a close production monitoring and focus on adding value to the construction period with smooth activities organization and deployment.

The E-Cockpit is linked to the RINNO Workflow process to ensure the Execution works to keep on track. The following key aspect are part of the global monitoring:

- Progress monitoring (resources, time, costs, etc.)
- Just-in-time Logistics
- Coworking and collaboration spatial organization on site
- Quality monitoring

As the E-Cockpit collects many data, a feedback will adjust the RINNO – AI module for a permanent increase of performance for current or future projects.

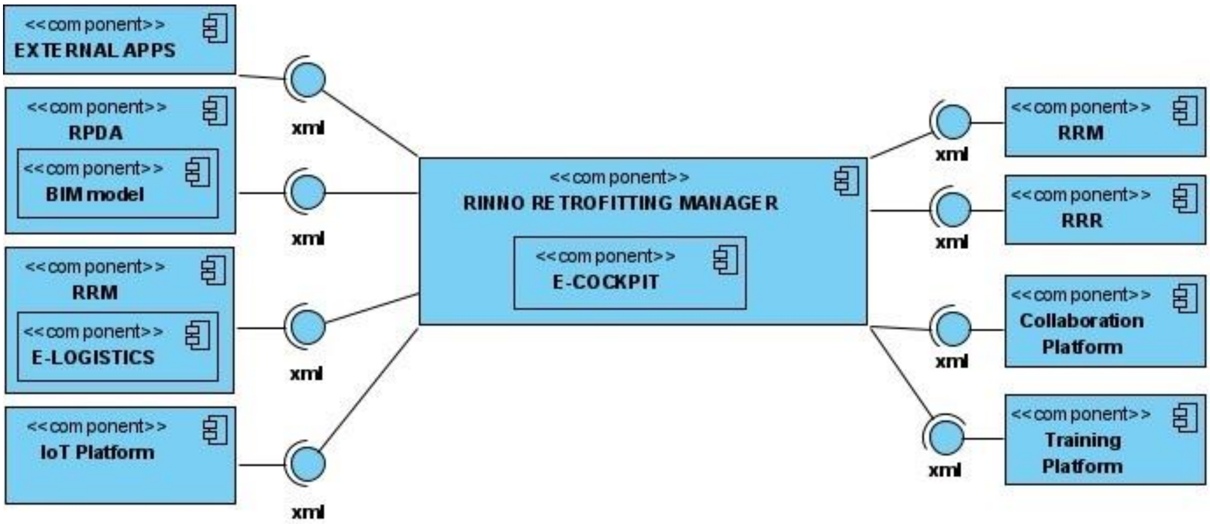

Figure 15 E-cockpit Component Diagram

The following tables explain in detail the main interfaces, and their interconnection with the RINNO Retrofitting Manager component.

Table 25 E-Cockpit - inputs

E-cockpit	Inputs Description
Orchestration	Central element of the e-Cockpit platform: Data acquisition for processing Broadcasting of information(streaming)

E-cockpit	Inputs Description
	The business logic and the processes to be implemented within the framework of the platform, possibly with access to the company IS and to third-party services.
Warnings & Notifications	Brick allowing to send an alert or a notification to a person, at the request of the orchestrator or following an event. An alert corresponds to a signal to be sent to a person on the site (site manager, for example) so that they act immediately in the event of danger or action required, with potential stoppage on the site in the event of danger. A notification corresponds to a message sent "for information" without immediate action required.
Services	Brick offering a set of production monitoring services for construction sites, which can be activated according to the desired configuration for a given site. It makes it possible to offer a modular and adjustable architecture with services such as: Control of security risks Site progress monitoring Assistance in piloting logistics the management of co-activities Others can easily be added later. This brick will manage the context and the correlation of the information received by e-Cockpit. Operation: The brick receives information tagged by the Orchestrator with the list of associated services that will have to process it. Thus, the same information can be used for assistance in the management of logistics and for monitoring the progress of the site, for example.
Administration	Administration module to perform: Managing objects, their attributes, and associated services Management of access rights to reporting to the administration platform (IAM: Identity and Access Management) Management of configurations and types of work sites, with the list of services activated or not on a work site, on an object, which are mandatory or optional, etc. Real-time monitoring of platform objects, active services, and overall platform status.

Table 26 E-Cockpit - outputs

E-cockpit	Output Description
Orchestration	This orchestrator will always therefore know: What services are activated for a given site To which services each data must be routed (by adding the appropriate tags so that the "Services" brick knows which pipelines to activate for processing) What additional treatments will need to be carried out for a specific use case (e.g.: once the manufactured objects have been recognized, call the BIM API to update it and ensure site monitoring).
Warnings & Notifications	An alert or notification can take the form of: • A push notification on a specifically developed mobile application. • A message • An email • A sound or light signal on the site.
Services	Each information is then transmitted via the corresponding module, to the associated processing pipelines. For example, the "progress" module will send to the RINNO Retrofitting Management pipeline, for comparison with the workflow and the planned schedule, then to the predictions with the trained model to identify the possible consequences of variations.
Administration	Escalation of notifications or alerts in case of unavailability of a brick of the solution, via the "Alerts and Notifications" brick. These management services will be exposed in the form of Rest API to be integrated with external bricks in the enterprise IS if necessary, in the future. These same APIs will be used to drive and manage these services via an administrative Web HMI.

3.2.3.4 Process Optimization

3.2.3.4.1 Optimization Strategy offsite/onsite

This tool is the background technology of the Recommendation Engine sub-module,. It consists of a multi-level decision framework. This tool is based on a excel document, where the user can score each criterion based on the project constraints. The first level (strategic level) conducts a feasibility study and evaluates the applicability of offsite construction. The second level (tactic level) proposes an integrated approach for the decision-making problem that combines the Analytical Hierarchy Process (AHP) and the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE). The combination of both approaches enables a careful evaluation of different construction methods and scenarios for the same project.

For the tactic level, it enables the decision maker to compare different industrialized solutions based on multi criteria decision methods. The decision maker finds the attributes of criterion in the AEC guides.

On top of this document, this tool will deliver:

- Offsite renovation score
- List of offsite drivers
- List of offsite constraints

Based on these results, the user will be able to decide clearly to offsite or onsite the renovation works.

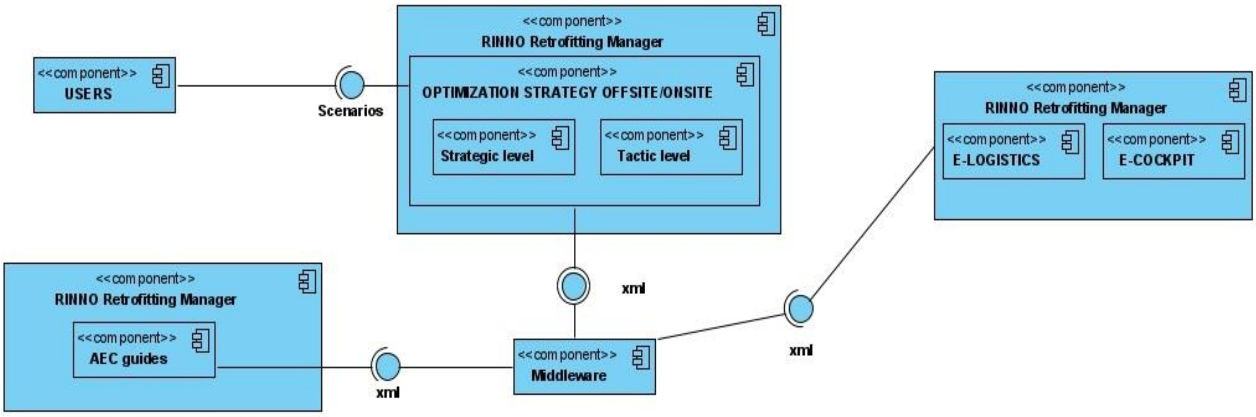

Figure 16 Offsite/Onsite strategy Component Diagram

The following table explains in detail the main interfaces, and their interconnection with this module.

Table 27 Offsite/Onsite strategy -inputs

Offsite/Onsite strategy	Inputs Description
User Input (strategic level)	• Economic Factors • Site-related factors • Design and structural factors • Factors related to the project. • Factors related to the deadline, planning. • Labour-related factors
User Input (tactic level)	• Number of floors • Experience and mastery of the solution • Competence of the available workforce • Climatic conditions • Transport • Corporate culture • Availability of lifting tools • Weight

	• Environment • Acceptability of the solution • Architectural/aesthetic form • Cost • Complexity of the construction • Speed / Planning/ Delay • Security • Quality • Repeatability • Relationship with the supplier

Table 28 Offsite/Onsite strategy - outputs

Offsite/Onsite strategy	**Output Description**
Output (strategic level)	An off-site construction score for the overall project as well as a score for each factor category. Two lists of factors: one list containing the factors that support off-site construction (the factors with the most positive weighted score) and a second list containing the factors that do not support it (the factors with the most negative weighted score).
Output (tactic level)	As a first step, it enables the importance of the different factors to be compared in order to weight them as objectively as possible, checking the consistency of the decision-maker's judgement. Secondly, this level allows to classify the compared alternatives.

3.2.3.4.2 E-Logistics

This sub-module is also part of RINNO Retrofitting Manager. It deals with the organization, display and tracking of all the material supply on and off site to allow risk minimization, lower costs and save space during the renovation process. The "E-logistics" platform will provide better control and overview of the whole supply chain during the renovation process addressing the related market need. To complement the renovation process optimization, the VIA-Process toolkit will be advanced to facilitate the whole lifecycle of the renovation process with an easy-to-use dashboard that will assign roles/tasks, solve any bottlenecks, and improve the engagement and monitoring of owners/users during renovation. This task forms the Process Optimization module of the RINNO Retrofitting Manager.

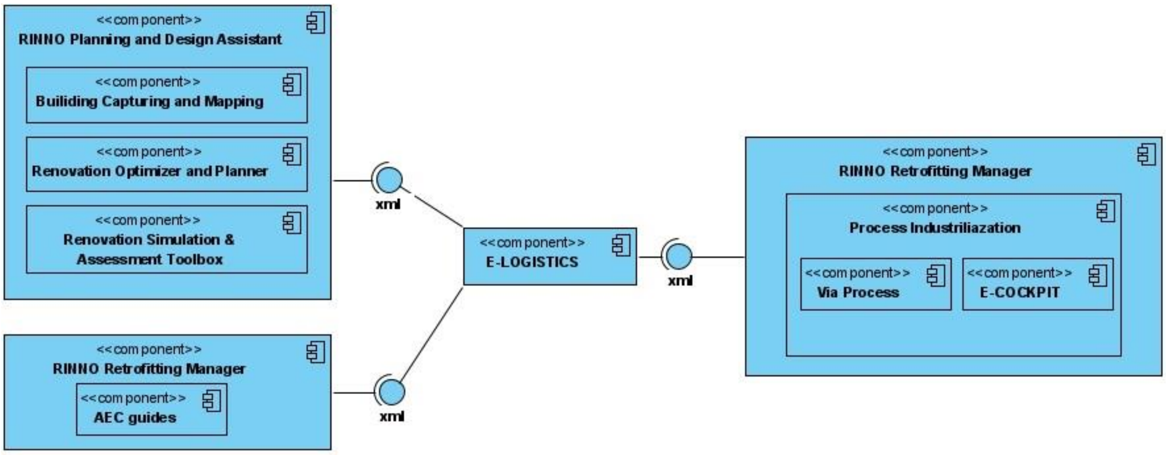

Figure 17 E-logistics Component Diagram

The following tables explains in detail the main interfaces, and their interconnection with the E-Logistics module.

Table 29 E-logistics - inputs

E-cockpit	Inputs Description
BIM Model	The e-logistics will use the quantities of materials, supplies to determine the period of manufacturing and installation.
Renovation Simulation and Assessment Toolbox	The e-logistics will check the solutions chosen for renovation, the suppliers selected for materials manufacturing and delivery.
AEC Guides	The e-logistics will use the installation and storage guidelines integrated into this guide to optimize the integration of technology on site.
Planning	The e-logistics will use the planning to coordinate all the deliveries and installations as per each task deadlines and project milestone.

Table 30 E-logistics - outputs

E-cockpit	Output Description
E-cockpit	The e-logistics and e-cockpit will have an important interaction in order to optimize the deliveries on site as per the real time progress on site to optimize storage and installation flow.
Via-Process	Via-process will be used to visualize the flow of operations measured and monitored by e-logistics.

3.2.4 Building Lifecycle Renovation Manager (BLRM)

3.2.4.1 Intelligent Renovation Assistant

Intelligent Renovation Assistant is the module of Building Lifecycle Renovation Manager. It follows the building renovation project through its whole lifetime. IRA consists of Renovation Validation and Benchmarking tool, Building Renovation Passports, Renovation Roadmap tool and Logbook Tool that allows to monitor and validate the renovation process, as well as generate information about the building. Accordingly, Validation & Benchmarking sub-module will get design data from RPDA and compare them with actual data. This tool will also collect and normalize data from all available renovated buildings to create a repository for benchmarking. In that way a building information (logbook) including historic, on-site or automatically generated data enabled by IoT is formed, in accordance with the Building Renovation Passports (BRPs) approach to follow a building throughout its lifetime. This leads to the formation of the Renovation Roadmap of the building.

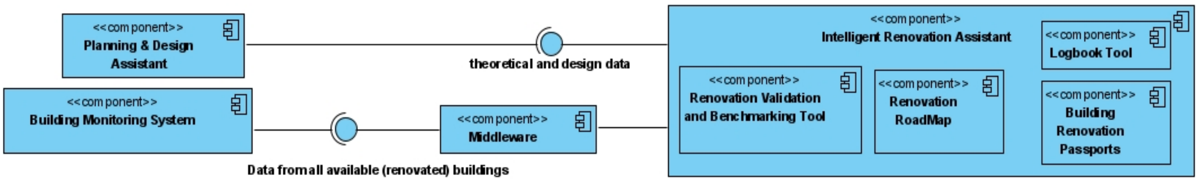

Figure 18 Intelligent Renovation Assistant Component Diagram

Table 31 Intelligent Renovation Assistant - inputs

Intelligent Renovation Assistant	Inputs Description
Theoretical and design data	Assistant gets from RPDA data from the design phase of renovation.
Data from all available renovated buildings	Assistant gets from Building Monitoring System data from the whole renovation history.

Table 32 Intelligent Renovation Assistant - outputs

Intelligent Renovation Assistant	Output Description
Renovation Roadmap	Renovation Roadmap includes systematic renovation solutions over a long period of time and in a sensible order aiming to achieve deep-staged renovation, in accordance with the BRPs approach.
Logbook	it will consist of an inventory of building-related information accompanied by technologies for managing/ monitoring real time parameters along with historical data.

3.2.5 Renovation Workflow & Transactions Manager (RWTM)

3.2.5.1 Renovation Workflow Manager (RWM) Tool

Renovation Workflow Manager (RWM) Tool is a module that belongs to the RINNO Renovation Workflow and Transactions Manager component. It enables information exchange and interoperability between RINNO Planning & Design Assistant (RPDA), RINNO Retrofitting Manager (RRM), and RINNO Lifecycle Renovation Manager packages.

The RWM tool allows the supervision of the whole lifecycle of the building renovation project by:

- Automating the quality assurance processes at all stages of the renovation project.
- Improving project coordination and project management reporting.
- Allowing project performance and data visualization.

Thus, technically the RWM tool should:

- Implement a documented collaboration format,
- Propose and implement a suite of associated verification libraries.
- Implement a cryptographic signature.
- Be equipped with dashboarding capabilities.
- Adopt a RESTful API infrastructure with Web service APIs.

This component will be developed based on the Deep Renovation Digital Plan (DRIP) platform whose main components are the Xbim Xplorer platform and the Digital Plan of Work (DPoW) as depicted in the schema below.

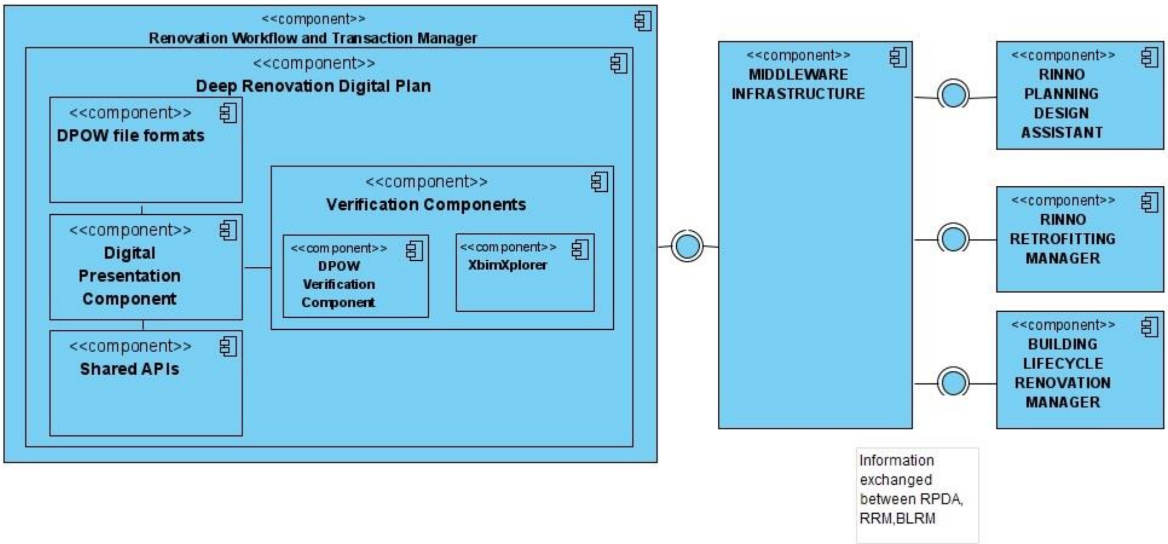

Figure 19 Renovation Workflow Tool Component Diagram

The following table explains the main interfaces, and their interconnection with the RWM component.

Table 33 Renovation Workflow Tool- inputs

Renovation Workflow Tool	**Inputs Description**
All information that should be exchanged between RPDA, RRM, and BLRM components.	The RWM tool will guarantee information exchange and interoperability between the main components of RINNO Suite, and during the whole lifecycle of the renovation project. BIM Model: this tool allows providing the BIM model from the IR definition stage, where it is just a set of information needs, until the operation and end of life stage.

Table 34 Renovation Workflow Tool- outputs

Renovation Workflow Tool	**Outputs Description**
All information that should be exchanged between RPDA, RRM, and BLRM components.	The RWM tool will guarantee information exchange and interoperability between the main components of RINNO Suite, and during the whole lifecycle of the renovation project. BIM Model: this tool allows providing the BIM model from the IR definition stage, where it is just a set of information needs, until the operation and end of life stage.

3.2.5.2 Renovation Transaction manager toolkit

Transaction Manager is a module of Renovation Workflow and Transaction Manager (RWTM). The establishment of simpler, more effective transactions will reduce transaction costs, will provide transparency, assurance and provenance, and thus better and more trusted collaboration without the need for a central authority or a legal system. Transaction Manager uses distributed ledger (blockchain-type) technologies in order to translate conventional agreements into smart contracts for automated transactions. Smart contracts will be used to enforce the agreements between the building tenants/owners and other stakeholders. Smart contracts will be based on Ethereum and will be used in Solidity to facilitate transactions among multiple parties. The RWTM will be developed based Distributed Ledger Technologies (DLT) and more specifically in an alternative approach called Ricardian Contracts. As a result, Transaction Manager will advance the integration between Smart Contracts and Ricardian contracts. It will also encode, and compile rules written in the Ricardian-type, human readable language into a functional, machine readable language that will be translatable to smart contracts in the next levels of the pipeline using appropriate compiler techniques and communication APIs.

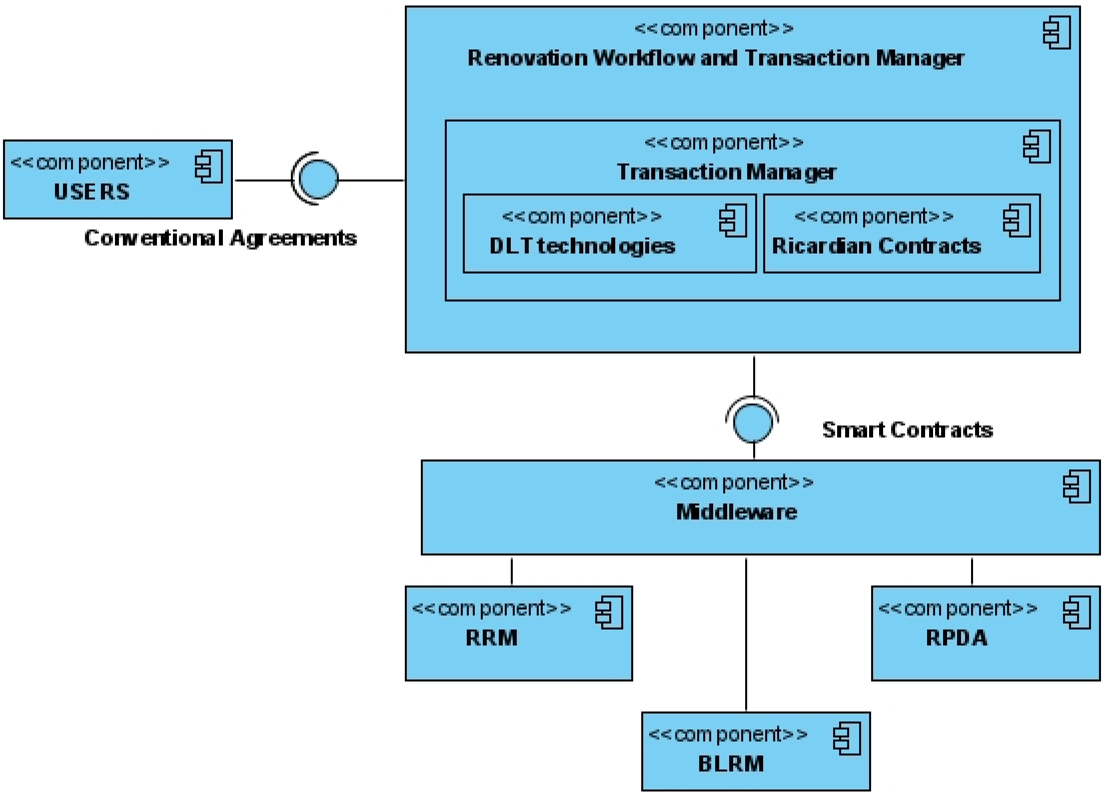

Figure 20 Transaction Manager Component Diagram

Table 35 Transaction Manager - inputs

Transaction Manager	Inputs Description
Conventional Agreements	Human readable agreements between stakeholders, tenants and participants e.g. renovation subcontractors.

Table 36 Transaction Manager - outputs

Transaction Manager	**Output Description**
Smart Contracts	Ethereum based smart contracts will be used to enforce the agreements between the building tenants/owners and other stakeholders (AEC). They will also be used in Solidity. RINNO will use the Ricardian Contracts approach.

4. Deployment View

Deployment view describes how and where the system will be deployed, which physical requirements are essential for the system to go live. Another important factor is the dependencies of the various components, modules, and sub-modules, their hardware requirements, and their physical constraints. In this view the physical environment where the system will run is defined, including:

- Hardware and Technical requirements.
- Mapping of software elements to the runtime environment.
- Third-party software requirements.
- Network requirements.

In this chapter it is analysed the deployment environment of the RINNO platform.

4.1 RINNO Main Components, Modules, and Sub-modules Deployment Environment & Hardware and Technical Requirements

4.1.1 RINNO Operational Interface with Augmented Intelligence

4.1.1.1 Social Collaboration Platform

Social Collaboration and Middleware are deployed on the Cloud Base Infrastructure of RINNO Suite the workstations and they are interconnected with a specialized intranet, that could be wired, wireless or a combination of both technologies.

It is important to mention that some HMIs, due to their huge, produced data (such as video content) they are connected directly to components that need this form of data since the Middleware will not be able to handle this type of information. Only metadata will be forwarded to the Middleware or even to the repository.

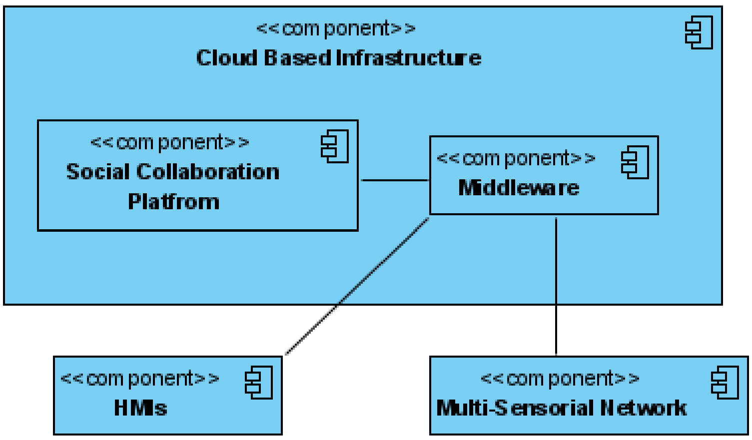

Figure 21 Social Collaboration Platform Deployment View

Table 37 Social Collaboration platform's Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6
Social Collaboration Platform	A PC workstation in the cloud with the following minimum requirements: • i5 CPU • 4GB RAM • 500 GB hard disk • Wi-Fi connection • Ethernet connection • USB connection • Windows 7 operating system or better

4.1.1.2 Marketplace

As shown in figure below, RINNO Marketplace is a cloud-based application interconnected with the Cloud Based Infrastructure of RINNO Suite. RINNO Marketplace connects with RINNO Renovation Repository directly.

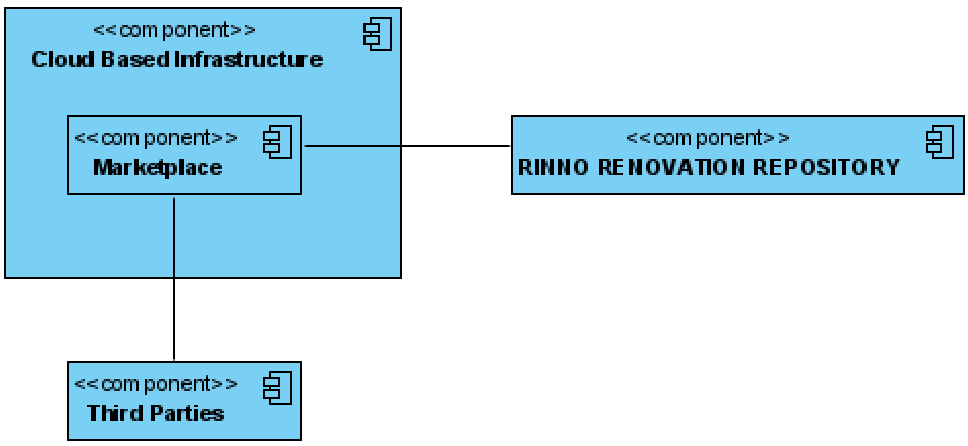

Figure 22 Marketplace Deployment View

Table 38 Marketplace Hardware and Technical Requirements

Name	Hardware and Technical Requirements
RINNO Marketplace	A PC workstation with the following minimum requirements: • i5 CPU • 4GB RAM • 500 GB hard disk • Wi-Fi connection • Ethernet connection • USB connection • Windows 7 operating system or better

4.1.1.3 Building Monitoring System

Building Monitoring System should be installed on the cloud based infrastructure of RINNO suite as shown in figure below. It connects directly with RINNO Planning & Design Assistant and feeds with data from the Building Performance Toolkit & Dashboard. Building Monitoring System gets data from the IoT devices through the Middleware installed in the Cloud Base Infrastructure of RINNO.

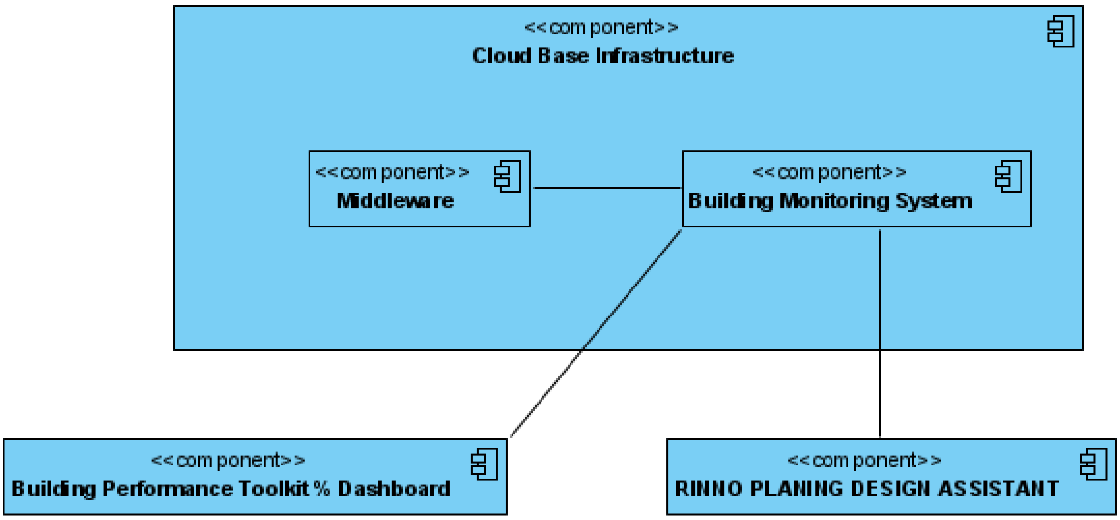

Figure 23 Building Monitoring System Deployment View

Table 39 Building Monitoring System Hardware and Technical Requirements

Name	**Hardware and Technical Requirements**
Building Monitoring System	A PC workstation one the cloud with the following minimum requirements: • i5 CPU • at least 8GB RAM • 500GB hard disk • Wi-Fi connection • Ethernet/Bluetooth connection • · Windows 10 operating system Use of open standard formats and libraries as • IFC • XML • COBie • XLS • bSDD • xBIMToolkit
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6

4.1.1.4 Central Dashboard

4.1.1.4.1 Building Performance Toolkit & Dashboard

Building Performance Toolkit & Dashboard should be installed on PC Workstation as shown in figure below. Building Monitoring System feeds with data the Building Performance Toolkit & Dashboard.

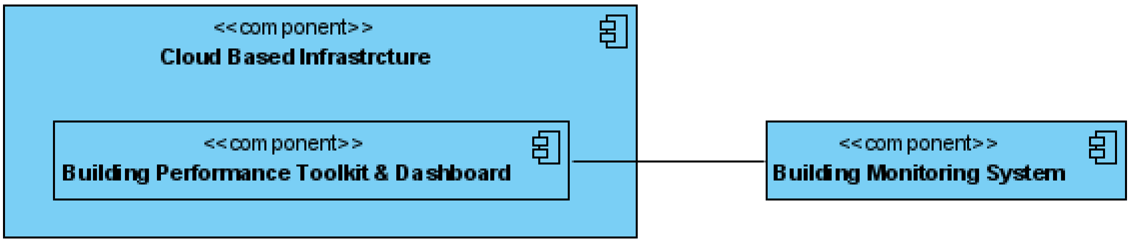

Figure 24 Building Performance Toolkit & Dashboard Deployment View

Table 40 Building Performance Toolkit & Dashboard Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Building Performance Toolkit & Dashboard	A PC workstation in the cloud with the following minimum requirements: • i5 CPU • 4GB RAM • 500GB hard disk • Wi-Fi connection • Ethernet connection • Windows 10.

4.1.1.4.2 AR/ VR User Interfaces (UIs)

This Section is referred to the User Interfaces (UIs), which will be delivered by the AR on-the-job training toolkit and it will be deployed as presented in Section 4.1.3.1.

4.1.2 RINNO Planning & Design Assistant (RPDA)

4.1.2.1 RINNO Renovation Optimizer and Planner Environment

The RINNO Optimizer and Planner component should be installed on a server machine, as it must be able to exchange data with the rest of the tools at any time. The server machine should be connected to the Internet or to a local network which interconnects the various tools and enables it to communicate with both the rest of the modules of the RPDA and the RWTM. The same machine that hosts some other tool of the RPDA can be used to host this module, too.

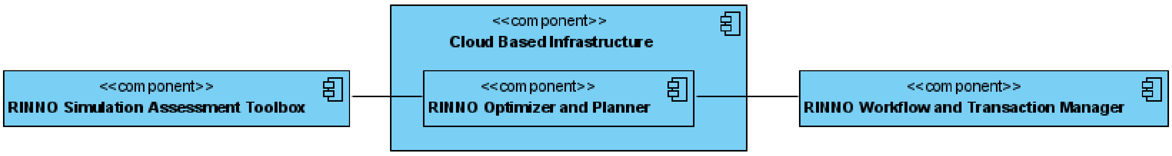

Figure 25 RINNO Renovation Optimizer and Planner's Deployment View

Table 41 RINNO Renovation Optimizer and Planner Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6

4.1.2.2 Renovation Simulation & Assessment tool

4.1.2.2.1 Energy Assessment tool

For the energy assessment tool, all required modules should be installed as shown in figure below, located in the Cloud Base Infrastructure of RINNO. As the tool will be utilized as a digital twin, a connection with the Multi-Sensorial Network will provide information to the cloud through the Middleware.

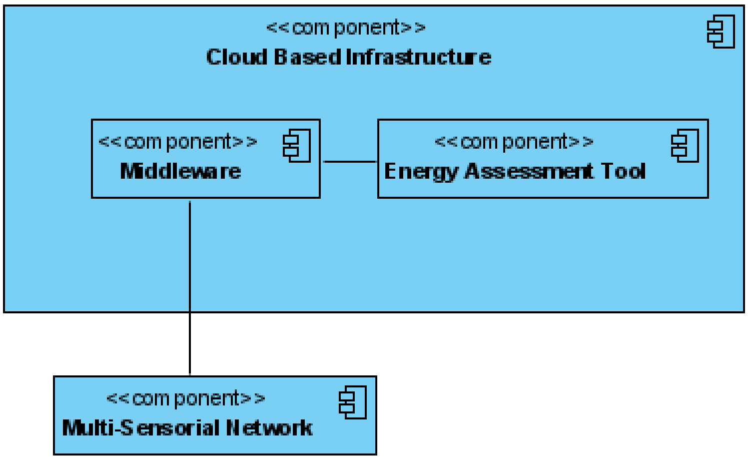

Figure 26 Energy Assessment Platform's Deployment View

Table 42 Energy Assessment Platform's Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Energy Assessment Tool	• Windows 10 operating system • Python Environment (e.g., anaconda or miniconda)
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6
Multi-Sensorial Network	A local installation with the following requirements: • Wi-Fi or Ethernet connection • Bluetooth connection • USB connection for direct connections to third devices (PCs, tablets, smartphones, other) • QUAD-CORE arm Cortex-A9 (set ARMv7) • 4GB RAM • 16GB ROM • Display 10" • Android 4.4 (KitKat) operating system

4.1.2.2.2 Techno-economical Assessment Tool

The Techno-Economical Assessment tool will be installed on the cloud to ensure the continuous exchange of data with the Renovation Modelling toolkit and to the RINNO optimizer and planner. The server machine should be always connected to the internet through Ethernet cable.

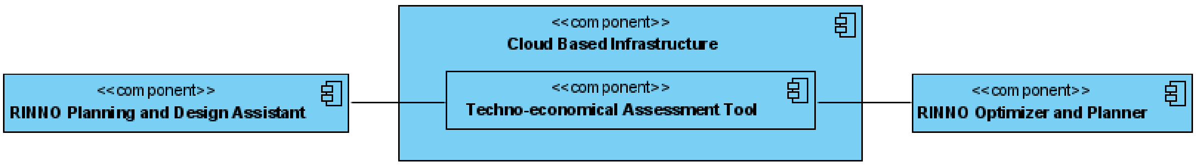

Figure 27 Techno-economical Assessment Tool Deployment View

Table 43 Techno-economical Assessment Tool Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6
Techno-economical Assessment Tool	• Windows 10 operating system • Python Environment (e.g., anaconda or miniconda)

4.1.2.2.3 Environmental, Cost and Social Assessment tool

Environmental, cost, and social assessment module will be developed under a web application framework scheme on the cloud. The full-stack framework will be able to execute Ruby and Python programming language, providing the ability to compute KPI's for the whole life cycle. The environmental, cost and assessment tool will be installed in a server machine, providing continuous access from and to the Renovation Modelling toolkit and to the RINNO optimizer and planner. The cloud infrastructure should be always connected to the internet through Ethernet cable.

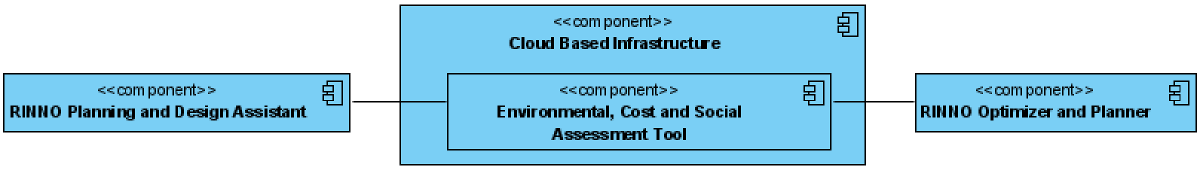

Figure 28 Environmental, Cost and Social Assessment Tool's Deployment View

Table 44. Environmental, Cost and Social Assessment Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3

Name	Hardware and Technical Requirements
	• Python 3.8.6
Environmental, Cost and Social Assessment	• Windows 10 operating system • Python Environment (e.g., anaconda or miniconda)

4.1.2.3 Renovation Modelling

4.1.2.3.1 Building Capturing and Mapping Deployment View

Building, Capturing and Mapping toolbox is installed in a PC workstation locally. It provides BIM model to the system in the form of Industry Foundation Classes (IFC) via the Middleware located in Cloud Based Infrastructure.

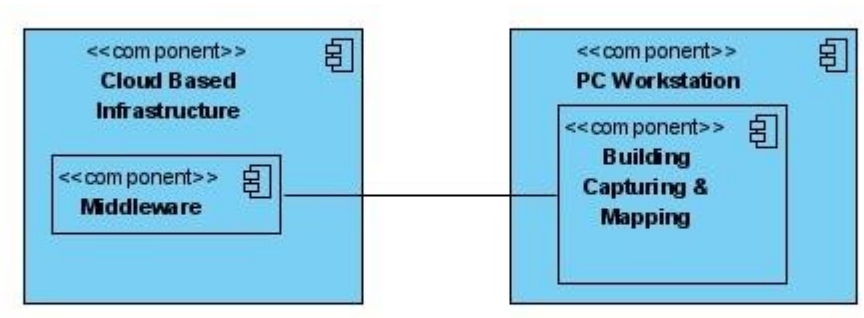

Figure 29 Building Capturing and Mapping Deployment View

Table 45 Building Capturing and Mapping Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Building, Capturing and Mapping toolbox	A PC workstation the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Use of open standard formats and libraries as • IFC • XML • COBie • XLS • bSDD • xBIMToolkit

4.1.2.3.2 Renovation Digital-Twin component Deployment View

Renovation digital-Twin sub module will be installed to the cloud-based infrastructure of RINNO suite and can be accessed through REST API web services.

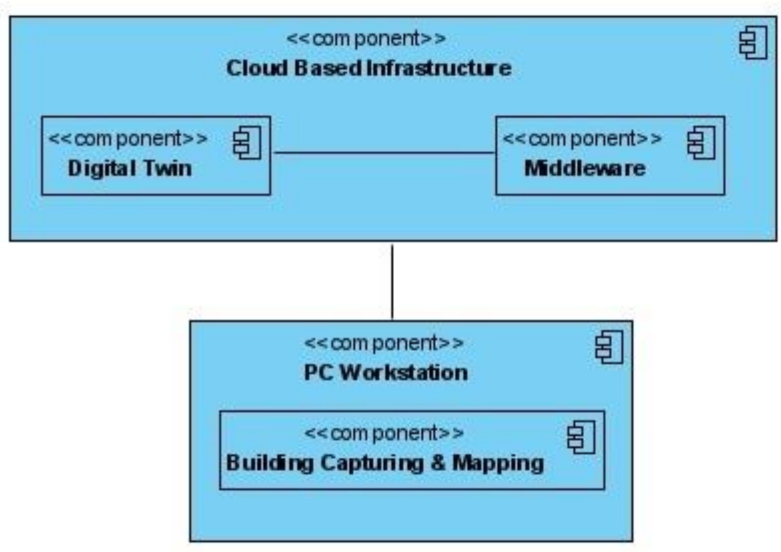

Figure 30 Renovation Digital Twin Deployment View

Table 46 Renovation Digital Twin Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6

4.1.3 RINNO Retrofitting Manager (RRM)

4.1.3.1 On-the-Job AR Environment

On the Job AR environment is installed locally and connects with the middleware on the Cloud Base Infrastructure of RINNO Suite.

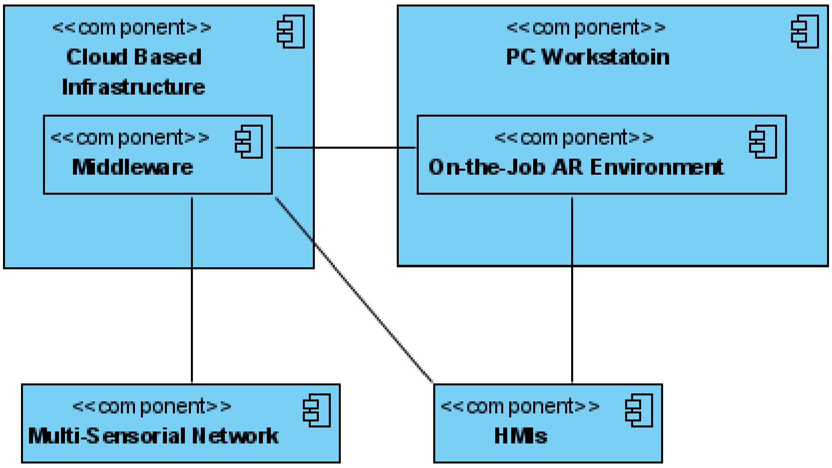

Figure 31 On-the-Job AR Environment Deployment View

Table 47 On-the-Job AR Environment Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6
On-the-Job AR Environment	• i5 CPU (last Generation) • 4GB RAM. • 500GB hard disk. • NVidia GPU GTX 650 2GB • Wi-Fi connection. • Ethernet connection. • Windows 7 operating system or better.

4.1.3.2 RINNO Retrofitting Manager Engine

As shown in figure below, the SCB platform is a cloud-based application and needs to be deployed on a server with all its components (Model, View, Controller and Advice Service components), interconnected with the Cloud Base Infrastructure of RINNO Suite.

The SQL Model (Database) size will be constrained by the physical hard drive space available. The number of concurrent connections including API posts, that the SCB can support is linked to the speed of which data can be queried and posted all have a relationship to the physical memory and CPU.

The Multi-Sensorial Network and a variety of HMIs can be in a local installation that will provide information to the cloud through the Middleware Infrastructure.

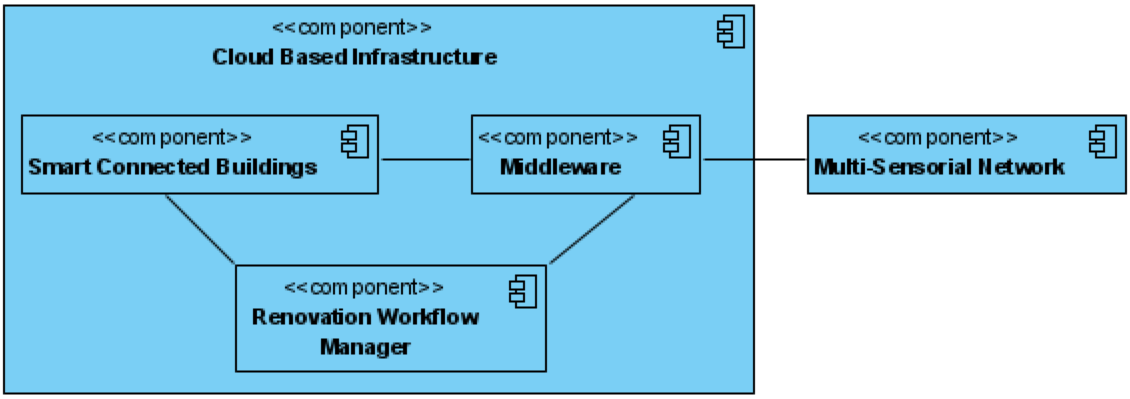

Figure 32 RINNO Retrofitting Manager Engine Deployment View

Table 48 RINNO Retrofitting Manager Engine Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Multi-sensorial Network	A local installation with the following requirements: • Wi-Fi or Ethernet connection • Bluetooth connection • USB connection for direct connections to third devices (PCs, tablets, smartphones, other) • QUAD-CORE arm Cortex-A9 (set ARMv7) • 4GB RAM • 16GB ROM • Display 10” • Android 4.4 (KitKat) operating system
SCB platform	A PC Workstation on the cloud will be needed with the following requirements: • i9

Name	Hardware and Technical Requirements
	• 32GB RAM • 5TB hard disk • Nvidia GeForce RTX 3080 10GB • Wi-Fi connection • Ethernet connection • Windows 7

4.1.3.3 Process Industrialization

The e-cockpit platform should be installed on the cloud as shown in figure below. It connects and exchanges data with other components and external apps in real time, through the Middleware installed in the Cloud Base Infrastructure of RINNO.

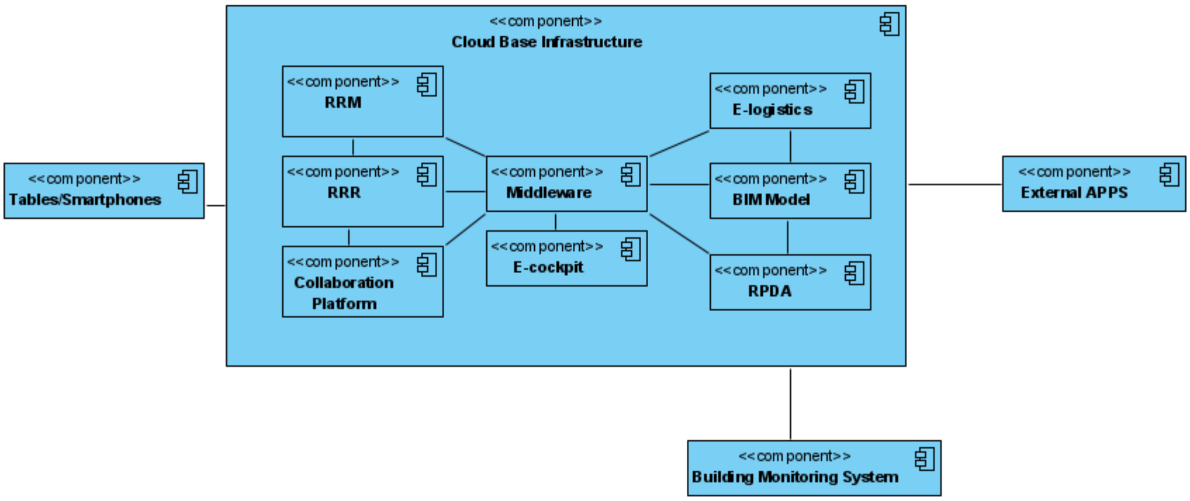

Figure 33 E-Cockpit Deployment View

Table 49 E-Cockpit Hardware and Technical Requirements

Name	Hardware and Technical Requirements
E-cockpit	A PC workstation on the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Use of open standard formats and libraries as • IFC • XML • COBie • XLS

4.1.3.4 Process Optimization

4.1.3.4.1 E-Logistics

The e-logistics platform is installed on the Cloud Base Infrastructure of RINNO Suite as shown in figure below. It provides information to the Transaction & Workflow Manager and to e-cockpit platform through the Middleware installed in the Cloud Base Infrastructure of RINNO.

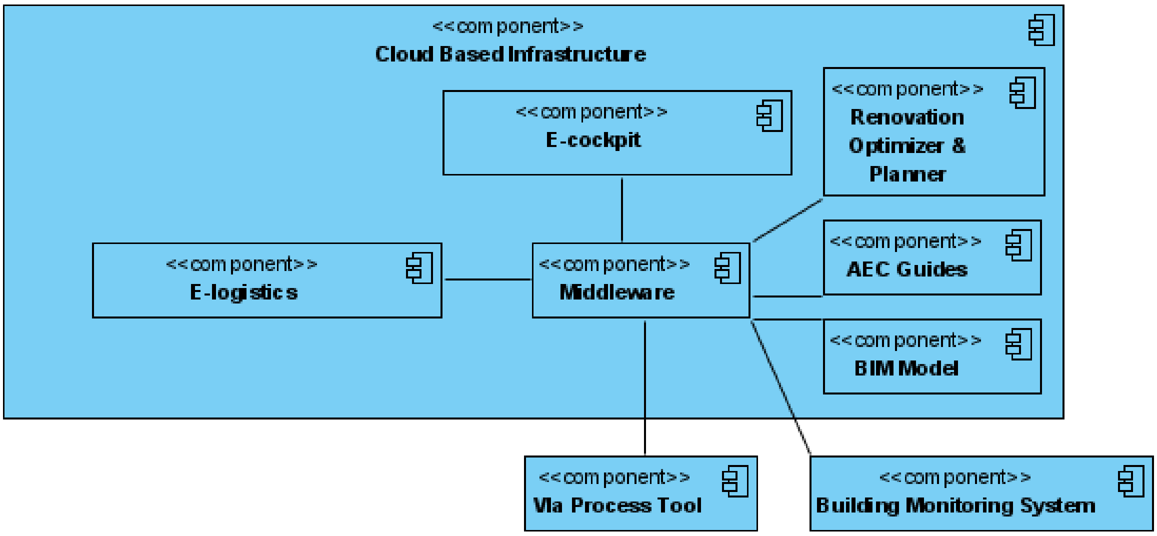

Figure 34 E-Logistics Deployment View

Table 50 E-Logistics Hardware and Technical Requirements

Name	Hardware and Technical Requirements
E-logistics	A PC workstation on the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Use of open standard formats and libraries as • IFC • XML • COBie • XLS

4.1.3.4.2 Optimization Strategy offsite/onsite

The tool installed on the cloud and will retrieve data from the AEC guide via the middleware the technical characteristics (installation, maintenance, performance...) of each technology and the rest of the input criteria will be identified by the user. All this to note each tactical and strategic phase to optimize the choice of the offsite/on site. The tool is in excel format with a detailed simulation via Python for the tactical phase. So, the output data will be converted itself into XML to feed the E-cockpit and E-logistics via the middleware.

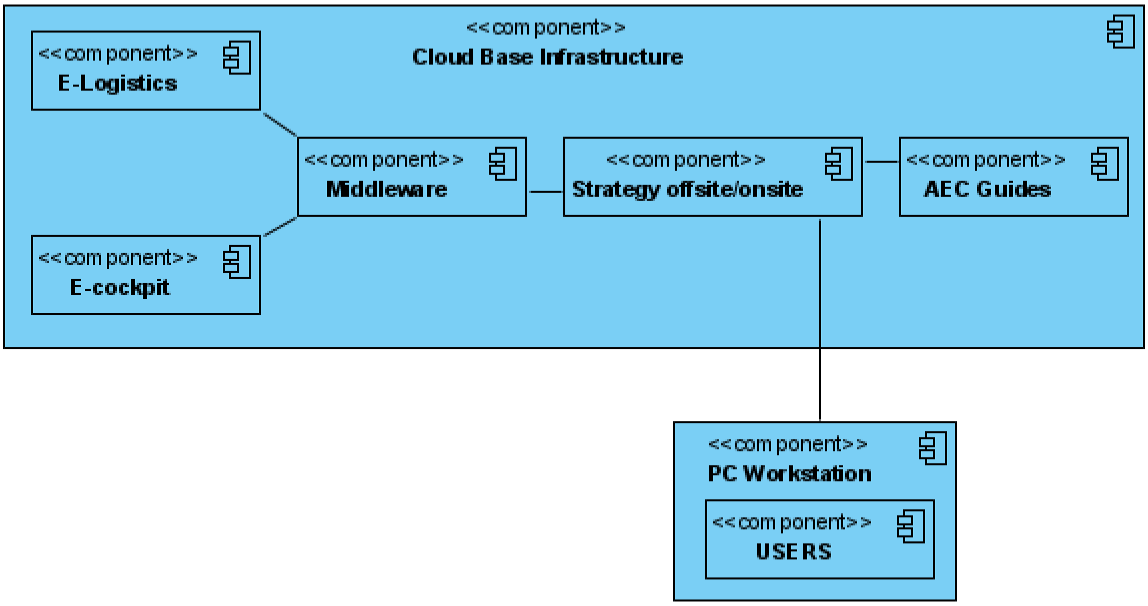

Figure 35 Optimization Strategy offsite/onsite tool Deployment View

Table 51 Optimization Strategy offsite/onsite tool Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Optimization Strategy offsite/onsite tool	A PC workstation on the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Use of open standard formats and libraries as • IFC • XML • COBie • XLS
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM

Name	Hardware and Technical Requirements
	• 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6

4.1.4 Building Lifecycle Renovation Manager (BLRM)

4.1.4.1 Intelligent Renovation Assistant

As shown in the figure below, Intelligent Renovation Assistant on the Cloud Based Infrastructure of RINNO. It interacts directly with RPDA and it connects with the Building Monitoring System through the Middleware installed in the Cloud Base Infrastructure of RINNO.

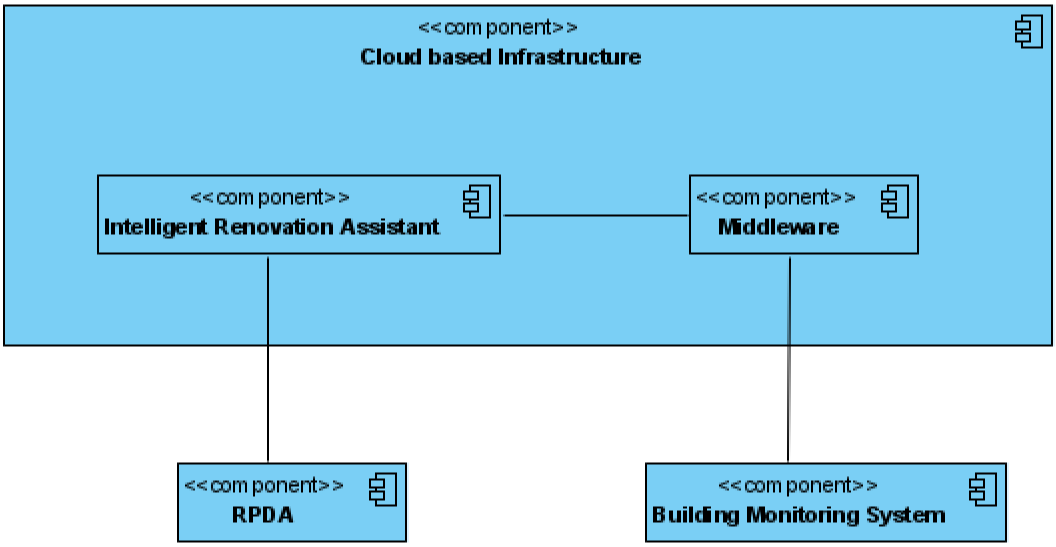

Figure 36 Intelligent Renovation Assistant Deployment View

Table 52 Intelligent Renovation Assistant Hardware and Technical Requirements

Name	**Hardware and Technical Requirements**
Intelligent Renovation Assistant	A PC workstation on the cloud will be needed with the following minimum requirements: • i5 CPU is preferable. • at least 4GB RAM • 500GB hard disk • Wi-Fi connection • Ethernet connection • Windows 7 operating system or better.
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6

4.1.5 Renovation Workflow & Transactions Manager (RWTM)

4.1.5.1 Renovation Workflow Manager Tool

As shown in figure below, the RWM platform is composed of two parts, one is cloud-based application (the Digital Presentation Component) and another desktop-based application installed locally, a set of verification tools, including the Xbim Xplorer component.

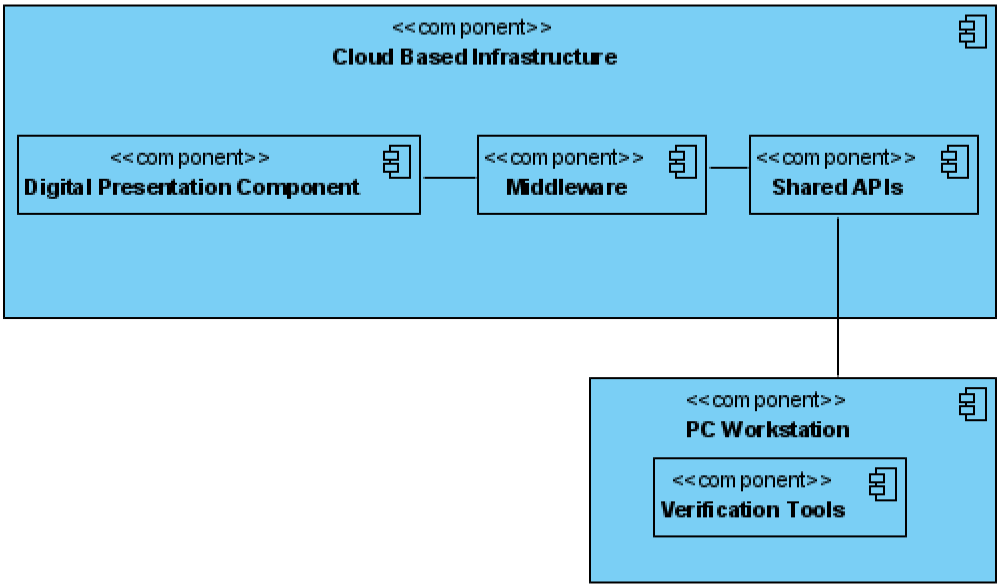

Figure 37 Renovation Workflow Manager Tool Deployment View

Table 53 Renovation Workflow Manager Hardware and Technical Requirements

Name	Hardware and Technical Requirements
Verification Tools	A PC Workstation on the cloud with the following requirements: • i9 CPU • 32GB RAM • 500GB hard disk • Nvidia GeForce RTX 3080 10GB • Wi-Fi connection • Ethernet connection • Windows 7
Digital Presentation Component	A PC Workstation on the cloud will be needed with the following requirements: • i9 • 32GB RAM • 5TB hard disk • Nvidia GeForce RTX 3080 10GB • Wi-Fi connection • Ethernet connection • Windows 7

4.1.5.2 Renovation Transaction Manager

As shown in figure below, the Transaction Manager is a web service module and needs to be deployed on a server with all its features, interconnected with the Cloud Base Infrastructure of RINNO Suite.

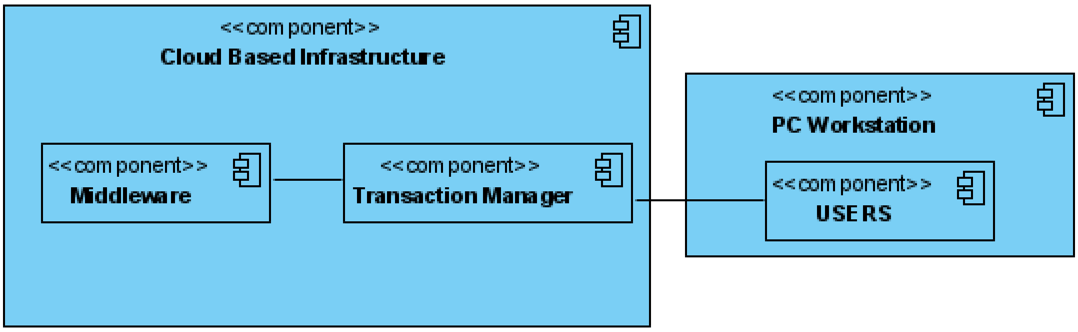

Figure 38 Renovation Transaction Manager Tool Deployment View

Table 54 Renovation Transaction Manager Hardware and Technical Requirements

Name	**Hardware and Technical Requirements**
Transaction Manager	• Windows 10 operating system • Solidity Compiler
Middleware	A PC workstation one the cloud the following minimum requirements: • I5 CPU • at least 8GB RAM • 250GB hard disk • Ethernet connection Ubuntu Server 18.04 or higher operating system with: • Ruby 2.7.0 • Rails 6.0.3 • Python 3.8.6

5. Information View

5.1 Overview of Information View

The figure below describes the data models and the data flow as well as their distribution. This viewpoint also defines which data will be stored and where. Information View will be presented with more details in the next versions. The interfaces, as well as inputs and outputs of the Information View will be labelled within next versions of the deliverable.

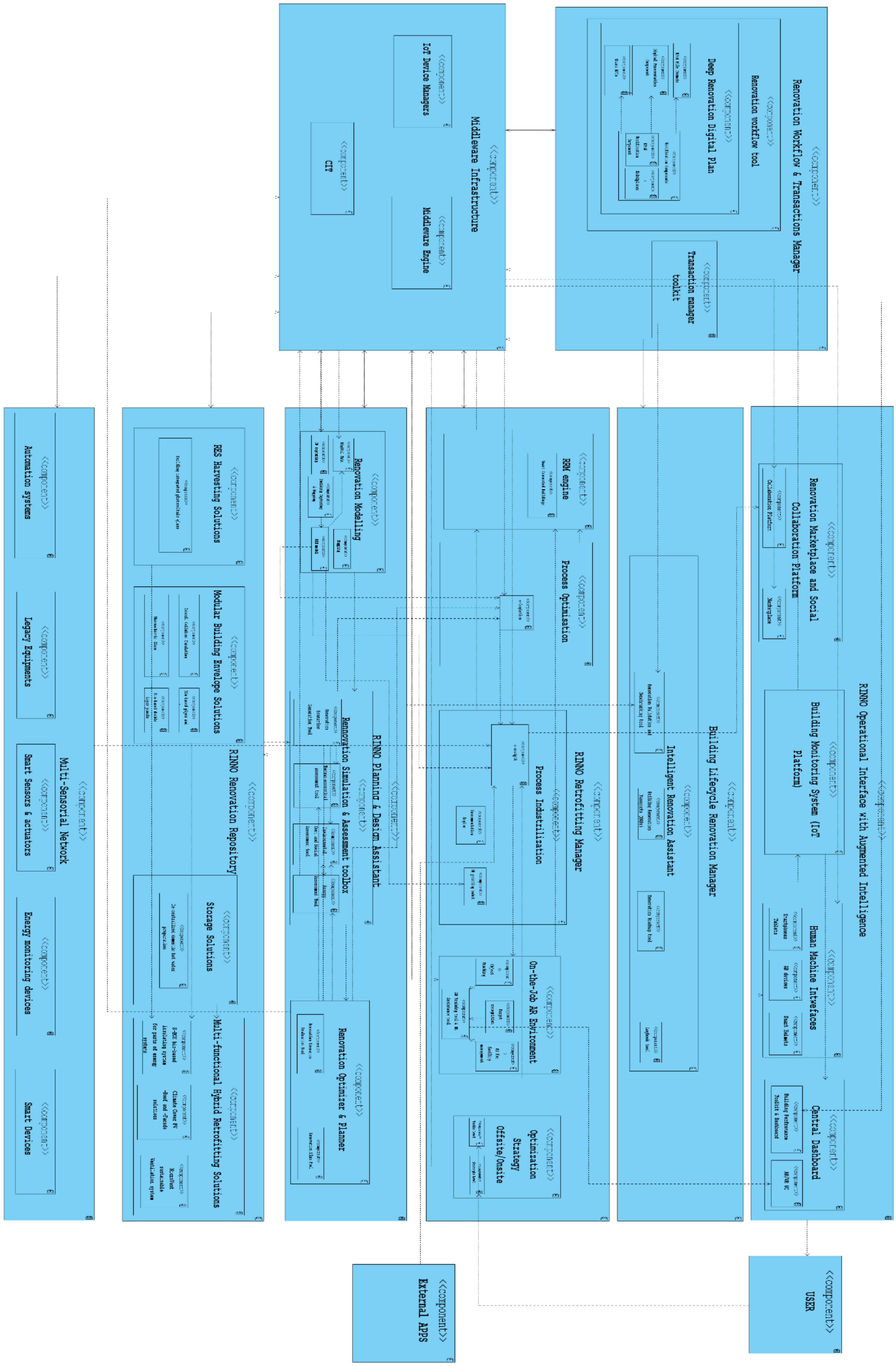

Figure 39 Overall Information View of Architecture

6. Conclusions

This document introduced the initial version of RINNO architecture. The first version of the architecture is divided in three phases.

In the first one, the phase of technology exploration, the purpose is to explore and analyse technologies relevant to the RINNO platform. Subsequently, some important architectural features can be identified at this phase and should be take into consideration during architecture definition. In the bottom-up phase, a set of components were defined by the responsible partners. In total, 4 main components and 12 modules along with various sub-modules were gathered. Every responsible partner delivered the internal architecture, the features, as well as the inputs and outputs along with a brief description of the main components, modules, and sub-modules. Accordingly, to this procedure, the RINNO architecture was divided in three different views (functional view, deployment view and information view).

Within next two versions of the RINNO architectural design, namely Deliverables D1.9 (M24) and D.10 (M36), the components will be revised according to the evolution and implementation of the components. It will be a living document, which will be revised until the finalization and the integration of the RINNO framework. To this end, the interconnection of RINNO components with details, especially at the communication part, will be presented, improving the descriptions of all three views, functional, deployment and information.

ABOUT RINNO

RINNO is a four-year EU-funded research project that aspires to deliver greener, bio-based, less energy-intensive from a life cycle perspective and easily applicable building renovation elements and energy systems that will reduce the time and cost required for deep energy renovation, while improving the building energy performance. Its ultimate goal is to develop, validate and demonstrate an operational interface with augmented intelligence and an occupant-centred approach that will streamline and facilitate the whole lifecycle of building renovation.

For more information, please visit **https://rinno-h2020.eu/**

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