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REVISION CONTROL

Version	Author	Date	Status

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1.0	Otilia Kytölä	August 19th, 2020	Submission to the EC

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ACRONYMS

Acronym	Meaning
AEC	Architecture, Engineering and Construction
API	Application Programming interface
ARIBFA	Augmented Reality-enabled In-situ Building Feature Annotation
BEP	Building Energy Performance
BICA	Building Information Collection Application for residents
BICE	Building Information Collection & Enrichment Component
BIF	BIMERR Interoperability Framework
BIM	Building Information Modelling
BIMERR	BIM-based holistic tools for Energy-driven Renovation of existing Residences
BIQB	Building Information Query Builder
BISP	Building Information Secure Provisioning
BMRR	BIMERR Requirements
BPMN	Business Process Model and Notation
BSM	Building Semantic Modelling
DoA	Description of Action
DIF	Data Ingester & Fetcher
DT	Digital Twin
EEB	European Environmental Bureau
EPW	EnergyPlus Weather file
EU	European Union
GAP	Grant Agreement Preparation
gRPC	general-purpose Remote Procedure Calls
HTTP	HyperText Transfer Protocol
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and Communication Technology
IFC	Industry Foundation Classes
IFD	International Framework Dictionary
KGG	Knowledge Graph Generator
KPI	Key Performance Indicator
LCC	Life Cycle Cost
LCA	Life Cycle Assessment
MEP	Mechanical, Electrical and Plumbing
MQTT	Message Queuing Telemetry Transport

MVD	Model View Definition
obXML	occupant behaviour eXtensible Markup Language
PESTEL	Political, Economic, Social, Technological, Environment and Legal analysis
PRUBS	Profiling Resident Usage of Building System
PWMA	Process/Workflow Modelling and Automation
RenoDSS	Renovation Decision Support System
R-CNN	Region-based Convolutional Neural Networks
RP	Reporting Period
SAREF	Smart Appliances REFerence
SenML	Sensor Measurement Lists
SoA	State of the Art
SWOT	Strengths, Weaknesses, Opportunities and Threats analysis
W3C	World Wide Web Consortium
WoT	Web of Things
WSN	Wireless Sensors Network

EXECUTIVE SUMMARY

This document reports the main achievements in the current reporting period (M1-M18, from January 1st, 2019 to June 30th, 2020) of the BIMERR project for the active WPs and the corresponding tasks.

For each WP, the objectives for the reporting period as well as an overview of the status and progress per task are provided. Any deviations from DoA and corrective actions taken by the partners are outlined, whereas planned activities for the next period are reported.

Furthermore, the project management activities, deliverables, milestones (including anticipated efforts for the next reporting period) and the use of human resources in terms of PMs spent by each partner per task and WP are provided.

1. EXPLANATION OF WORK CARRIED OUT BY THE BENEFICIARIES & OVERVIEW OF THE PROGRESS

1.1 SUMMARY OF THE PROJECT RATIONALE

BIMERR will design and develop an ICT-enabled Renovation 4.0 toolkit comprising tools for AEC stakeholder support throughout the energy efficiency renovation process of existing buildings. It will enforce semantic interoperability among its own tools as well as with third-party ICT tools to enable seamless BIM creation and information exchange among the AEC community in an effort to boost the rapid adoption of BIM in renovating of the existing EU building stock.

BIMERR relies on three key elements in order to achieve its objectives:

1. ***Interoperability throughout the BIM ecosystem*** and more specifically between *renovation-support tools* and *digital building model creation tools* (as well as beyond the BIMERR system, see Figure 1) to ensure information exchange in a semantically and syntactically coherent manner compliant to the various tool interface specifications and more importantly, compliant to a unified standard which defines a unique, consistent and complete specification of renovation-related information;
2. ***Renovation process improvement*** through innovative methods and tools for:
   a. *automated and synergistic creation of the digital building model* (enhanced BIM) of existing buildings to counter the arguably, the largest obstacle in the initiation of any BIM-based renovation project, which is the lack of adequate digital models as the basis for all activities;
   b. *adaptive project-specific and dynamic cost/time optimization of the renovation process & workflow* to enhance collaboration, assist in the early detection of costly mistakes and facilitate process optimization via flexible & realistic process models that enable what-if scenario exploration (for design-time process optimization, but also construction-time process adaptation for dealing with unexpected or unpredictable events, e.g. weather conditions, logistics problems, etc.).
3. ***Innovative renovation-support tools for end-users*** (AEC professionals, residents) to lower barriers for the proliferation of building renovation activities by:
   a. raising awareness about the potential gains in energy consumption, emissions and cost savings which will facilitated by the provision of easy-to-use tools for the assessment of renovation options impact on the building by the owners/residents themselves – without the need to call on professional help for a first estimation of benefits; this will convince more citizens to go ahead with such projects and will likely also enhance the DIY home renovation movement across Europe by democratising tools for easy investigation of alternative options and selection of the optimal one for any constraint,

b. reducing risks of under-performance via improved projection of the post-renovation energy consumption of the building accounting for the actual usage characteristics, time/cost excesses.

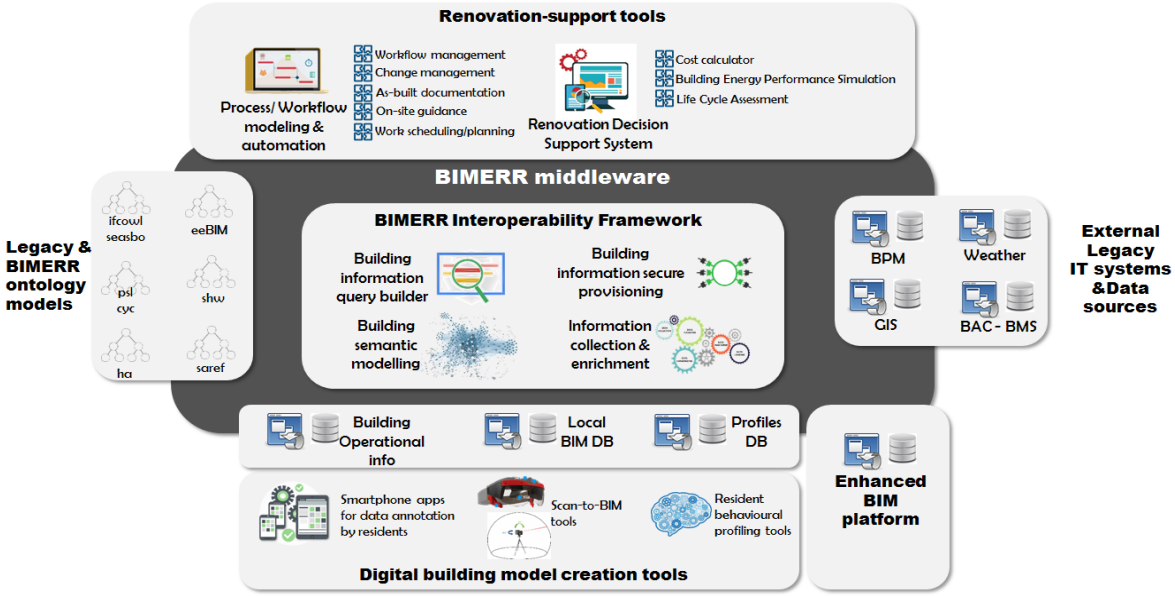

Figure 1 The BIMERR concept

To satisfy the requirements for efficient and effective renovation of existing buildings, BIMERR will develop, deploy and demonstrate an ICT ecosystem that includes tools supporting activities from digital building model creation to design support for renovation designers and construction work planning and workflow management. All these tools rely on the availability of information flows that transcend specific tools and provide a common semantic anchor to ensure the interoperability and semantic coherence of information interpretation across tools and stakeholders.

Figure 1 illustrates the high-level BIMERR concept in the form of abstract functional components. Its main purpose is to describe the functionality and responsibilities of the various system components, including the heart of the system: the BIMERR Interoperability Framework (BIF).

The ***Renovation-Support Tools*** lie at the top of the figure. These applications will facilitate the renovation process from the design phase to delivery of the renovated building and documentation to be the owner/operator. BIMERR foresees the design and development of two customer application kits for two major stakeholder classes.

The **Renovation DSS (RenoDSS)** aims to become a necessary Computer-Aided Design companion of the renovation designer and end beneficiary (e.g. building owner or operator). It will simultaneously quantify and cumulatively assess the impact of energy efficiency related renovation options (e.g. replacement of HVAC systems, envelope elements, insulation materials) on the building economic, energy and life-cycle management metrics so as to provide the user a holistic and long-term view on renovation impact. By taking into account the actual (as-is) building characteristics, its operational/usage patterns, information about its installed equipment and its past usage/degradation as well as information about weather patterns in the building vicinity, connections to utility networks and interaction with other buildings, RenoDSS can improve on the accuracy of estimations and projections of conventional tools that use only rated information from datasheets and factor additional externalities in the renovation design process that will account for urban/network planner considerations.

The **Process & Workflow Modelling & Automation (PWMA)** toolkit facilitates the construction phase of the renovation project and is mostly targeted to renovation planners, project managers and construction contractors/workers. It includes:

i) a back-end application for the modelling and adaptive monitoring of the entire renovation process as well as information management that will ensure synchronization of up-to-date information across tool & stakeholders leading to delivery of as-built documentation after works are complete;
ii) dedicated applications targeted to stakeholders in the renovation site (contractors/workers & building residents) to provide on-site guidance so as to expedite the works through better synchronization of different activities and real-time works monitoring and reporting to facilitate information flow, enhanced collaboration and early conflict detection.

It is evident that the aforementioned tools rely on a lot of heterogeneous information to achieve their objectives. Each of the tools has specific information requirements, which will be specified in a data model template/schema.

The **BIMERR Interoperability Framework (BIF)** will be responsible for ensuring the semantically and syntactically coherent information flow among the components of the BIMERR system as well as external, legacy IT systems. The BIF contains four main building blocks (as seen in Figure 1) that will: i) manage information queries from the renovation support tools, ii) perform semantic modelling and annotation of data models, ii) populate

data models from heterogeneous sources based on semantic links, and iv) deliver the populated models to the requestor tools in the appropriate manner. BIF will also be responsible for the interfacing with legacy IT systems in order to extract necessary information that is already available, but requires semantic annotation and linking before it can be associated with the renovation project/building under investigation. More information about the details of the BIF functionalities can be found in Section 1.3.3.1.

The actual interfacing between all the BIMERR component as well as external systems will be performed by the **BIMERR middleware**, as indicated in the figure. Its purpose is twofold: i) to facilitate the communication flows between applications, and ii) to enforce the appropriate data privacy & security requirements.

Finally, the bottom layer of the Figure 1 (***Digital Building Model Creation Tools***) depicts applications and tools that will be developed during the project and will create the necessary building models for the renovation design and planning activities. This is a critical step in the process, since lack of a digital representation of the building render all aforementioned tools useless. BIMERR foresees the development of innovative tools for automatic and manual extraction and annotation of building features on digital models, including: i) novel scan-to-BIM techniques for automated BIM population and feature annotation using thermal images, ii) Augmented Reality enabled applications for the building surveyor using which a simple in-situ building inspection will significantly improve the accuracy of existing models and annotate building features that are not possible via scanning, iii) behavioural profiling tools to understand how resident use the building and its systems, and iv) apps for the residents where they can annotate building information they find important based on their everyday activities within the building. The enhance BIM platform will be based on the bimserver.org open-source implementation which will be appropriately extended and configured to cover the BIMERR data modelling and storage needs.

Beyond the project technical activities that focus on the design and development of the aforementioned system, **standardization activities will be extensively carried out by two BIMERR partners** with strong links to the most important international standardisation bodies in this domain. FER (a linked third party of BX) is a full member of the buildingSMART alliance, the international home of OpenBIM and the main entity behind core BIM standards, such as IFC, IFD, MVD and so on. UPM participates in several

standardisation bodies related to data semantics in the building/ construction domain, namely i) ETSI SmartM2M TC, where it leads SAREF ontology (and extensions) development; ii) buildingSMART Linked Data WG; iii) W3C Linked Building Data CG; and iv) W3C Spatial Data on the Web IG. These networks and participations will be leveraged by the BIMERR consortium in two manners: i) to understand standardization needs and bring them in BIMERR activities as requirements, and ii) to promote the BIMERR outcomes for inclusion in future standards editions.

1.2 OBJECTIVES AND KEY OUTPUTS

The following overall objectives taken from section 1.1 of the BIMERR Grant Agreement are still valid and achievable by the project:

- **Objective 1**: Facilitate the acceleration of the renovation trend in order to meet the EU policy objectives by demonstrating the BIMERR tools in actual renovation sites to prove their impact and providing best practise examples to the AEC community.

  Key Outputs:
  1. Demonstration and evaluation of BIMERR toolkit in real renovation projects;
  2. BIMERR tool evaluation results;
  3. BIMERR tool user acceptance estimated by the project evaluation methodology;
  4. Best practise examples of the use of BIMERR tools.

- **Objective 2**: Establish semantic interoperability among the diverse popular standards, formats and data models in the construction industry and reach out to standardization bodies with concrete and demonstrated proposals for linking and mapping them toward a unified way to retrieve building information.

  Key Outputs:
  1. Survey and analysis of EEB-related ontologies, data modes and standards;
  2. Definition of data models/ontologies for operational building aspects deriving from resident behaviour;
  3. BIMERR Interoperability Framework;
  4. Standardization punch-list and promotion to relevant bodies/committees;

- **Objective 3**: Develop innovative methods, techniques, and tools for the (semi-) automated creation of enhanced digital building models of existing buildings to remove one of the main barriers to renovation.

Key Outputs:

1. Enhanced scan-to-BIM tools
2. Automated profiling of resident usage of building systems (PRUBS) tool
3. App to collect building & usage information from residents (BICA)
4. AR-enabled in-situ building feature annotation (ARIBFA) app

- **Objective 4**: Deliver novel renovation support tools to ease and improve the efficiency of the renovation process for all stakeholders involved.

  Key Outputs:

  1. Renovation Decision Support System;
  2. Building Energy Modelling accounting for resident behaviours;
  3. Renovation process & workflow management tools;
  4. On-site support to workers via AR-enabled applications;
  5. Automated building digital model creation tools.

- **Objective 5**: Promote the adoption of the BIMERR solution as renovation-enabling toolkit through intense dissemination and knowledge transfer of the project outcomes toward the targeted stakeholders, reaching out to audiences within and beyond the EU.

  Key Outputs:

  1. Training activities in renovation sites in PL & ES;
  2. Living Lab activities boosting reach and dissemination of project outcomes;
  3. Workshop with standardisation bodies;
  4. BIMERR exploitation plan;
  5. Promotion of BIMERR results in standardization bodies.

1.3 KEY INDICATORS AND QUANTIFIED TARGETS

The BIMERR project aims at achieving the objectives listed above progressively throughout three Reporting Periods (RP), RP1 [M01 – M18], RP2 [M19 – M36], and RP3 [M37 – M45]. Table 1 shows BIMERR's measurable objectives, their corresponding set of achievement indicators as well as the RP during which the indicator is to be implemented and can be verified at the end. Please notice that details on the milestones referred to on Table 1 are presented on Table 4.

Table 1 BIMERR Measurable objectives

Obj.#	*Indicator*	*RP1*	*RP2*	*RP3*
1	MS12: Selection of buildings	x		
	MS4: Selection of real renovation projects for demonstration activities		x	
	MS6: BIMERR validation and evaluation complete			x
	Demonstration of 80% renovation cost savings			x
	Demonstration of 30-35% renovation time savings			x
	BIMERR tool user acceptance exceeding 95% as measured during use in real renovation projects			x
	At least 10 best practices of BIMERR usage obtained from the validation activities			x
	Demonstration and evaluation in 4 buildings (2 undergoing real renovation)		x	x
	BIMERR demonstrated in buildings in 3 EU member states		x	x
2	MS 5: Delivery of refined BIMERR system after pre-validation feedback		x	
	MS8: Standardization punch-list		x	x
	Analysis and linking/mapping of the 10 most relevant data models, exchange formats, standards and ontologies	x	x	
	1 BIMERR workshop in Spain with the participation of standardization bodies' representatives			x
	Promotion of BIMERR results in 3 standardization bodies/ organizations		x	x
3	MS5: Delivery of refined BIMERR system after pre-validation feedback		x	
	Prototypes of 4 tools for feature extraction and digital building model population		x	
	Demonstration & validation of tools in 4 residential pilot buildings in 3 countries with different climatic zones		x	x
	Contribution to reduction of cost savings by 80%			x
	Contribution to reduction of renovation time by 30-35%			x
4	MS1: End-user requirement elicitation & documentation	x		
	MS5: Delivery of refined BIMERR system after pre-validation feedback		x	
	MS6: BIMERR validation & evaluation			x
	2 individual BIMERR tools developed and delivered (RenoDSS & PWMA)	x	x	
	Achievement of user acceptance levels of at least 95% for BIMERR tools during demonstration on real-life renovation projects			x
5	MS11: Project website launched	x		
	MS7: Public Awareness, Dissemination & Engagement Planning	x		
	MS9: Business innovation plan		x	x
	At least 2 training seminars (1 per renovation site) to be held			

Obj.#	Indicator	RP1	RP2	RP3
	for AEC stakeholders			
	3 Living Lab workshops	x	x	x
	1 BIMERR workshop to be organised in Spain with the participation of standardization bodies' representatives			x
	Promotion of BIMERR results to at least 3 standardization bodies		x	x
	Achievement of Technology Readiness Level 6 for BIMERR system			x

The achievement of BIMERR RP1 objectives can be assessed against the deliverables released during the Reporting Period as summarized in Table 2 below. Please notice that details on the deliverables and on the milestones referred to on Table 2 are presented on Table 3 and Table 4, respectively.

Table 2 BIMERR Results – Achievement of BIMERR RP1 objectives

Obj#	Indicator	RP1
1	MS12: Selection of buildings	**MS12** – achieved: pre-validation and validation sites have been selected. First version of the Pilots Report is ready, and the Letter of Interest is signed (for the validation sites).
	MS4: Selection of real renovation projects for demonstration activities	MS4 is due M23. However, Pilot-sites' partners have started collecting detailed information about the target buildings that have been selected; for the pre-validation sites, owner and occupants have committed to participate in validation activities.
	MS6: BIMERR validation and evaluation complete	Although the evaluation and impact assessment of the BIMERR tools based on the results obtained from the use in real renovation projects will be delivered during the RP3 (M42), the BIMERR consortium has designed an overall evaluation methodology to be followed, issued on M10 (**D3.3**).
	Demonstration of 80% renovation cost savings	
	Demonstration of 30-35% renovation time savings	
	BIMERR tool user acceptance exceeding 95% as measured during use in real renovation projects	
	Demonstration and evaluation in 4 buildings (2 undergoing real renovation)	Although pre-validation activities start on M24, the consortium agreed on progressing with the data collection of the pre-validation buildings (also performing the laser scanning) and partially demonstrating some tools of WP5.
2	Analysis and linking/mapping of the 10 most relevant data models, exchange formats, standards and ontologies	**D3.2** – a survey and a first analysis of existing data models and ontological representations. **D4.1** – a preliminary data requirement analysis defining the general scope of the BIMERR ontologies and data models and their coverage by existing data schemas while identifying an initial set of ontologies and data models on

Obj#	Indicator	RP1
		which BIMERR may build upon. **D4.2** – The first version of BIMERR ontologies has been defined and methods to convert it to the BIMERR data models used in the BIF have been developed. The ontologies are being published, and updated at https://bimerr.iot.linkeddata.es.
3	Prototypes of 4 tools for feature extraction and digital building model population	Both the first and the final versions of the as-is building information extraction & model population tools will be delivered during the RP2. However, all tools of WP5 have shown significant progress in the RP1 (see section **1.4.7**).
	Demonstration & validation of tools in 4 residential pilot buildings in 3 countries with different climatic zones	Although the evaluation and impact assessment of the BIMERR tools based on the results obtained from the use in real renovation projects will be delivered during the RP3 (M42), the BIMERR consortium has sketched an overall evaluation methodology to be followed, issued on M10 (**D3.3**).
	Contribution to reduction of cost savings by 80%	
	Contribution to reduction of renovation time by 30-35%	
4	MS1: End-user requirement elicitation & documentation	**MS1** achieved: the stakeholder requirements for the BIMERR system have been documented in D3.1 issued on M06 and updated in M18.
	MS6: BIMERR validation & evaluation	Although the evaluation and impact assessment of the BIMERR tools based on the results obtained from the use in real renovation projects will be delivered during the RP3 (M42), the BIMERR consortium has sketched an overall evaluation methodology to be followed, issued on M10 (**D3.3**).
	Achievement of user acceptance levels of at least 95% for BIMERR tools during demonstration on real-life renovation projects	
	2 individual BIMERR tools developed and delivered (RenoDSS & PWMA)	**D6.1** - Report on process/workflow management tools for renovation support **D6.2** – the first version of the adaptive renovation process & workflow models **D6.4** – the first version of the renovation process simulation tool. Note here that RenoDSS and additional PWMA toolkit components will be delivered in the RP2. However, all tools of WP6 and WP7 have shown significant progress in the RP1 (see sections **1.4.8** and **1.4.9**).
5	MS11: Project website launched	**MS11** – achieved (https://bimerr.eu/): Public access to project Website – Details have been documented in D10.1.
	MS7: Public Awareness, Dissemination & Engagement Planning	**MS7** – achieved: Details have been documented in D10.2 and D10.3
	MS9: Business innovation plan	The BIMERR business innovation plan will be report in D10.10 (M24) and D10.11 (M42) under T10.4. In the RP1, a dedicated **questionnaire** has been circulated to project partners, and valuable information has been collected the

Obj#	Indicator	RP1
		relevant information to be consolidated at the business model and value proposition designs
	3 Living Lab workshops	The first living lab workshops took place in Spain and Poland – Details can be found in **D10.6** (issued on M13).

1.4 ACHIEVED RESULTS DURING 1ST REPORTING PERIOD

The project is implemented with activities being performed in ten work packages (WP), each divided in a variable number of tasks (2 to 5 per WP). The first WP (WP1 – Ethics requirements) was added during the Grant Agreement Preparation (GAP) process to deal with ethics in the project.

Figure 2 shows the WP structure: WP2 handles quality assurance and project management and it rules over all other WPs, WP10 is about dissemination, exploitation and standardization activities. WP3 generates inputs (such as stakeholders' requirements and architecture design) towards the BIMERR tools being built in WP4-7. WP8 handles the integration, testing and pre-validation of the BIMERR tools, whereas validation and evaluation are carried out in WP9.

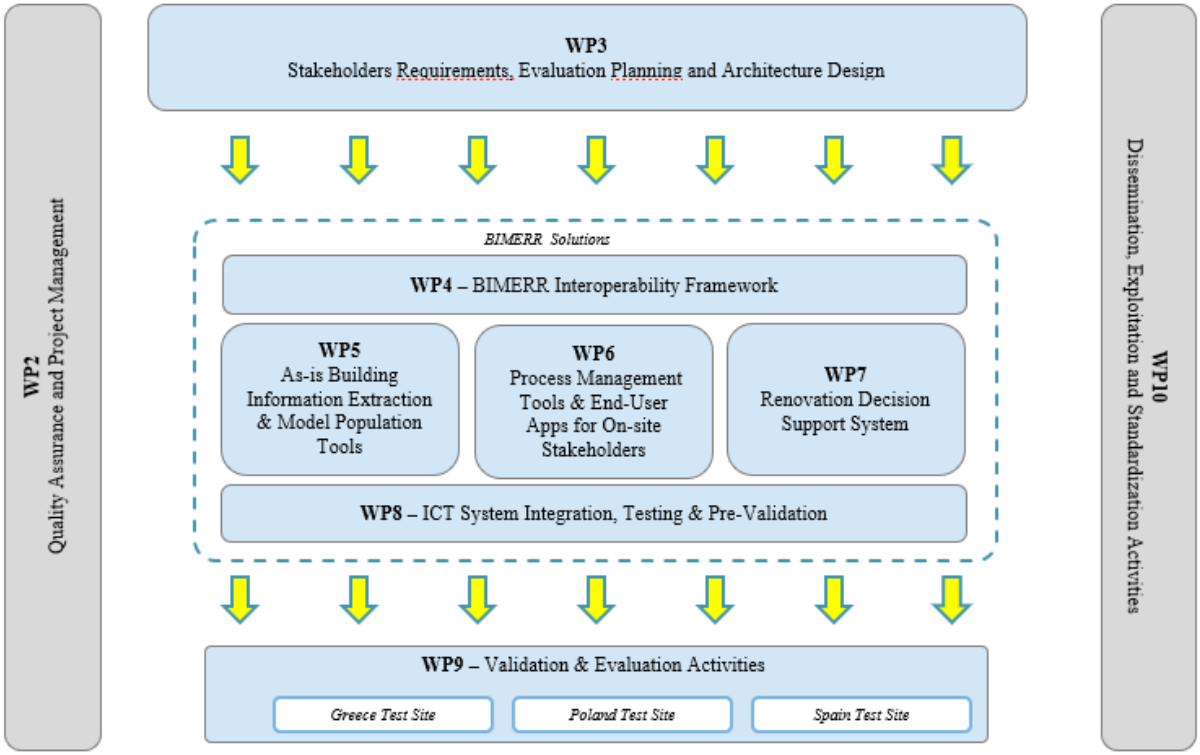

Figure 2 BIMERR work package structure

A summary of the work carried out by the project in this first reporting period is provided by Table 3 and Table 4 which enlist the deliverables and milestones issued by the project.

Table 3 Deliverables submitted to the European Commission in the 1st reporting period of the project

Del. no	Deliverable name	WP	Lead Beneficiary	Dissemination level	Delivery date from Annex 1	Actual/ Forecast submission date
D1.1	H – Requirement No. 1	WP1	FIT	CO	M06	M06
D2.1	Quality Assurance Plan	WP2	FIT	CO	M03	M03, revision M07
D2.2	Periodic Report 1	WP2	FIT	CO	M09	M09
D2.5	Periodic and Financial Report	WP2	FIT	PU	M18	M20
D3.1	Stakeholder requirements for the BIMERR system	WP3	UOP	PU	M06	M06
D3.2	Survey of data models,	WP3	UPM	PU	M08	M08

	ontologies and standards in the wider Energy Efficient Buildings domain					
D3.3	BIMERR evaluation methodology	WP3	UOP	PU	M10	M10
D3.4	Analysis of renovation tools market and prevailing regulatory frameworks	WP3	EXE	PU	M07	M07
D3.5	BIMERR system architecture 1st version	WP3	CERTH	PU	M12	M15
D4.1	Report on Semantic Alignment & Linking of EEB-related Ontologies	WP4	UPM	PU	M10	M11
D4.2	BIMERR Ontology & Data Model 1	WP4	UPM	PU	M15	M15
D4.4	BIMERR Building Semantic Modelling tool 1	WP4	SUITE5	PU	M16	M17
D4.6	BIMERR Information Collection & Enrichment Tool 1	WP4	SUITE5	PU	M16	M17
D4.8	Integrated BIMERR Interoperability Framework 1	WP4	UBITECH	PU	M18	M18
D6.1	Report on process/workflow management tools for renovation support	WP6	BOC	PU	M13	M13
D6.2	Adaptive renovation process & workflow models 1	WP6	BOC	PU	M16	M17
D6.4	Renovation process simulation tool 1	WP6	BOC	PU	M18	M18
D10.1	BIMERR branding, website and social media channels	WP10	MERIT	PU	M03	M03
D10.2	BIMERR dissemination and communication plan and associated material 1	WP10	MERIT	PU	M06	M06
D10.3	BIMERR dissemination and communication plan and associated material 2	WP10	MERIT	PU	M18	M18
D10.6	BIMERR Living Lab activities evaluation Report 1	WP10	MERIT	PU	M12	M13

Deliverable D7.1 – Populated Material/Component Databases 1 was planned to be delivered on M13 under the leadership of EXE. Due to EXE's termination and the need for tasks'

reallocation to a new partner, this deliverable has been officially postponed to M20 through an amendment.

In the kick-off meeting held in January 2019, the consortium decided that the deliverable D3.1 - Stakeholder requirements for the BIMERR system – would be issued as planned in M06, but its content should be updated in M18 in a 2nd version. The content of D3.1 is described in section 1.4.1.1.

Table 4 Milestones achieved during the 1st Reporting Period

ID	Title	Leader	Due month	Status
MS1	End-user requirements elicitation & documentation	UOP	M06	Achieved M06
MS2	BIMERR system architecture definition	UOP	M12	Achieved M15
MS7	Public Awareness, Dissemination and Engagement Planning	MERIT	M06	Achieved M06
MS10	Quality Assurance Plan	FIT	M03	Achieved M03
MS11	Project website launch	MERIT	M03	Achieved M03
MS12	Selection of buildings	BX	M12	Achieved M17
MS13	Use Cases and Scenarios ready	UOP	M12	Achieved M10

The remainder of this section summarizes the progress of the work, by addressing the main contents of the deliverables generated by the technical work packages (WP3 to WP9) and by describing how such contents have been progressively used by the project to move forward. The progress of the work in this reporting period is structured into *foundations*, *advances in the BIMERR Platform, and groundwork on* validation & *evaluation*. Progresses in the area of Ethics (WP1), Project Management (WP2) as well as in the area of Dissemination, Exploitation and Standardization (WP10) are available in sections 2.1, 2.2, and 2.10, respectively.

1.4.1 Foundations

1.4.1.1 BUSINESS SCENARIOS, USE CASES AND REQUIREMENTS

Within BIMERR, the Living Labs approach has been adopted, since it engages end-users from the early stages of any new idea, cultivating motivation to share and discuss experiences as well as requirements. Two traditional requirements elicitation techniques are employed in the context of the Living Labs: a) requirements focus workshops; and b) online surveys. Both are supported by carefully structured questionnaires that were derived with support of the

technical partners to reflect their information needs. The steps of the requirement elicitation process involved consultation with the consortium partners during several teleconferences to produce five business scenarios from the high-level business objectives of the project:

- BS1: Construction companies and/or architectural studios to reduce time and cost of renovation projects design procedures;
- BS2: Construction companies to reduce the time and cost of project planning processes (from permissions to materials order) through standards-based communication with all involved stakeholders;
- BS3: Construction companies to reduce time and cost during renovation and commissioning works;
- BS4: Increase workforce and occupants' safety during renovation works; and
- BS5: Construction companies and/or architectural studios to accurately predict the energy performance of renovated buildings and continuously update their predictions based on real data, towards making more attractive the energy performance contracting model.

These were subsequently expanded to sixteen appropriate use cases that lead the development of the respective components of the BIMERR framework, based on feedback provided by the consortium partners involved in each use case. Example use cases include UC-01: 'Rapid scanning of the geometry of the building, semantic modelling and accurate representation in a BIM' and UC-05: 'Accurate scheduling of activities and assessment of their efficiency through simulation and verification'. Additionally, for each BIMERR use case, the following information is provided: a use case description, related business scenarios and business impact, involved user group, involved BIMERR tools, pre and post conditions, use case path, leading and contributing partners, realization priority level.

From the use cases, 17 groups of end-users emerged, which were subsequently grouped into 7 main user groups (architect, BIM modeller, building surveyor, project manager, site manager, worker, occupant), based on feedback from the pilot partners and criteria such as the homogeneity of the work challenges and work environment of each end-user involved in the building renovation process. Based on the described renovation process that included 7 phases (ranging from building auditing and architectural design to operation and maintenance) along with the involved user groups, a series of suitable end user questionnaires were produced in four languages (English, Polish, Spanish, Greek) in order to capture the views and requirements of each BIMERR main user group. Hence, first we considered the results from the four focus workshops held in Poland (2) and Spain (2) with total 45 participants across the different user groups, and further analysed the different

viewpoints of the stakeholders in order to produce a non-exhaustive qualitative list of user requirements. This process was then also supported with a more quantitative approach with the help of responses to on-line questionnaires from 106 stakeholders, including occupants.

The analysis of the feedback led to the definition of 151 requirements. These were then separated per user group, different types of priority /importance ranging from High (essential in order to achieve the goals of the project since they define the core aspects of the system) to Medium and Low, as well as on different types such as Functional (system functionalities that the users require), Performance, Design Constraint, Operational, Legal, Process, and Pilot Specific., (e.g. BMRR-5, Architect shall be able to exchange information with site manager, is Functional with High priority).

All the analysis and the results for the BIMERR user requirements are described in the two versions of D3.1 (as agreed by the consortium in the kick-off meeting). The version of D3.1 delivered in M06 was based on the feedback received from the first workshop organised in Warsaw, Poland, and resulted in 112 user requirements. The updated and final version of D3.1 was ready for submission in M18 and contains requirements elicited based on extended stakeholders' feedback from 3 additional focus groups, two in Spain and one in Poland as well as responses from 106 online questionnaires, that resulted in 151 user requirements.

1.4.1.2 MARKET AND REGULATION ANALYSIS

A market research and analysis of AEC regulations in the UK and several EU countries, especially Poland and Spain where the BIMERR pilot sites are located, and at a lesser extent in Greece where the pre-validation activities are held, have been performed. That survey identified the key directives to drive the use of BIM within renovation activities, the involved stakeholders, the market size and potential, needs and value propositions that BIM-based Renovation support tools must fulfil. The mandates of all European countries, involving the use of BIM tools, as well as all the legal and regulatory frameworks and directives of the EU federally and nationally, were reviewed and consolidated.

The aforementioned market and regulation survey considered a PESTEL analysis for Poland and Spain, whose findings provided the indications for potential exploitation pathways of BIMERR results in these countries.

Furthermore, BIM mandates, energy renovation regulations and directives were reviewed, while a SWOT analysis of BIMERR in the targeted markets was performed. The work above was reported in D3.4 "Analysis of renovation tools market and prevailing regulatory frameworks" which was delivered on time in M7.

1.4.1.3 BIMERR DATA MODELS, ONTOLOGIES AND STANDARDIZATION

First steps planned in BIMERR DoA towards the definition of the BIMERR ontologies and data models was to review existing resources, focusing on well-known ones and those provided by standardization bodies, in order to have a first impression of the formats, data models and standards that might be relevant for the project. Such survey has been documented in D3.2 which was generated in a highly collaborative way by all partners participating in the task, coordinated by the task leader. It should be mentioned that this analysis was mostly exploratory and oriented to BIMERR related domains in a high level, as at that point no use cases nor explicit data exchange requirements were defined.

A more detailed analysis has been carried out taking as input D3.2 and BIMERR use cases during T4.1 to give a more accurate view of how existing resources could fit BIMERR data modelling needs. In this step it was observed that new domains should be taken into account, for example project management, just looking at the use cases, that is, the more precise are the data requirements more resources might be taken into account or decision about potential resources to be reused might change.

The continuation of the BIMERR ontologies and data models is taking place in T4.2, in which the ontologies are being defined and enriched in order to be converted to the BIMERR data models used in the BIF. The ontologies are being published, and updated at https://bimerr.iot.linkeddata.es. These ontologies are being built following agile processes prioritizing tasks according to the project needs. The methodology followed combines ontology development techniques with software development tools and practices. The methodology and intermediate results are reported in D4.2. Currently there are 6 ontology published, reusing 9 existing ones and one additional ontology used for BIMERR internal annotations to synchronize the public ontologies with the data model used by BIF. In addition, there is a first version of the ontology to data model converter.

Even though the task for preparation and promotion for standardization has recently started the participation in standardization bodies has been active in W3C Web of Things working group and the Linked Building Data community group.

1.4.1.4 EVALUATION METHODOLOGY

The BIMERR evaluation methodology considers the tools of the BIMERR platform and is designed based on well-established international methodologies and protocols, reviewing the current status and relevant BIM projects, as well as reviewing relevant renovation works and expertise of the BIMERR constructor partners. This way, the BIMERR methodology creates a robust framework that enables the definition of adequate KPIs required to assess the BIMERR performance. The use of BIMERR tools in real renovation works in the context of the use cases proposed in D3.1 was considered along with the four major impact KPIs described in the DoA, i.e. reduction of renovation process duration, reduction of the renovation process cost, improvement of user acceptance and increase in energy efficiency. For each of them a list of complementary KPIs along with the necessary input parameters and the required calculations have been produced following an iterative methodological approach with feedback from the partners at task as well as consortium, level. In particular, the evaluation of user acceptance follows an empirical approach that is based on the analysis of users' characteristics and project goals, while incorporating the typical constructs for perceived usefulness and ease of use. Overall, the following numbers have been identified: 31 KPIs related to renovation time and cost (17 of them are also linked to BIMERR tools accuracy); 14 KPIs related to energy efficiency; 26 KPIs related to user acceptance; 8 KPIs related to occupants comfort; 10 KPIs related to sustainability; and economic KPIs.

Furthermore, ways to capture this information during the piloting activities have been identified (historical data collection, sensor measurements, user feedback via the provided purpose made questionnaires, simulations), also providing the necessary baselining.

Note here that following the DoA, fine tuning of the evaluation methodology with extensions and refinements, tailored to the selected pilot buildings' characteristics in Spain and Poland, will be carried out in the pilot activities of WP9.

1.4.2 Advances in the BIMERR Components

1.4.2.1 BIMERR ARCHITECTURE

The work on the BIMERR System Architecture Design & Elaboration started on M4 of the project and involved all technical partners of the consortium. Within the first reporting period, after several weekly discussions and iterations, the main high-level architecture scheme of the entire system was drafted and based on this, the intermediate-level architecture schemes of the main building blocks of the system. On the highest level, the BIMERR architecture is comprised of 5 main components:

- the BIMERR Interoperability Framework (BIF);
- the BIMERR Middleware;
- the Digital Building Modelling Tools;
- the Renovation Support Tools; and
- the BIMERR UIs.

For the intermediate level, starting with the Use case definitions and the requirements documented in the work of T3.1, the survey of existing data models and ontologies from T3.2, the evaluation methodology from T3.3 and the analysis of regulations and markets from T3.4, each partner designed and documented their sub-component's specifications, functionalities, inputs and outputs within the overall architecture and within each main component it belongs to. The high-level architecture diagram as derived through that process is depicted in Figure 3.

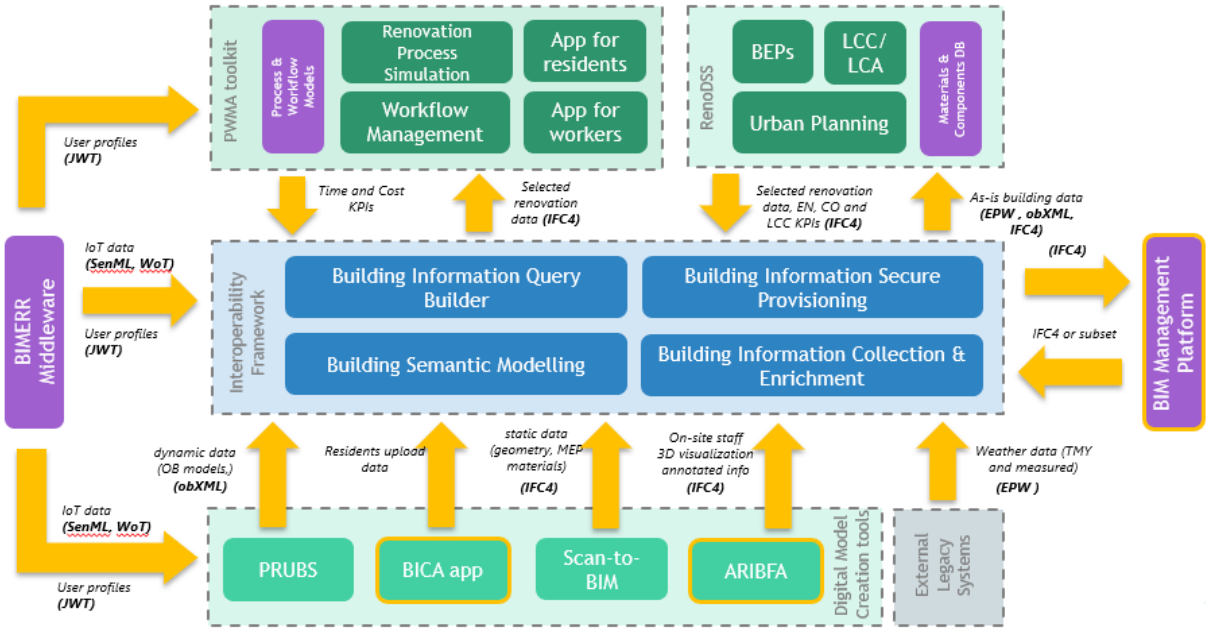

Figure 3: BIMERR High-level Architecture

The high-level architecture diagram was followed by an analysis of each component's role in the system in order to define the architecture into two main views: the structural view, describing the core components of the system in the form of software modules, and the dynamic view, which presents the already defined use cases with the corresponding sequence diagrams.

The work above has been complemented with an overview of the Data Exchange and Interoperability requirements, including data flow, protection, and privacy requirements, along with a preliminary Data Protection Impact Analysis. Finally, roadmaps detailing the development milestones of each sub-component were defined and reported in order to be able to monitor the progress of each component and how it impacts the overall architecture.

The culmination of the work described above was the delivery of D3.5 "BIMERR System Architecture". Due to the departure of GU and EXE from the project, this deliverable's submission was postponed to M15 from its original planned delivery date of M12. The second version of the system architecture (D3.6) is planned to be delivered on time in M20.

1.4.2.2 BIMERR MIDDLEWARE

The middleware, as a collection of components, realizes integration requirements in a micro-service architecture. The services may be deployed on edge (inside buildings or apartments) or cloud infrastructure depending on the use case. BIMERR provides cloud instances[1] (as part of FIT infrastructure) for the middleware to be used during the development, pre-validation, and pilot phases. Below are the short descriptions, implementations, and deployment status of four components that have been realized in this period. Other components for device abstraction and over-the-air gateway update capabilities will be implemented in the next period.

Historical Datastore

The storage component of the middleware, called the Historical Datastore, is a lightweight, distributed component for time-series IoT data storage. The core idea behind this component is to store data as close to the producer (apartment) as possible and only migrate the data toward fog (building level) and cloud when necessary. The data migration is be based on pre-defined processes and available computational resources to protect both the privacy of personal data and reduce operational costs. The component currently provides APIs for three protocols (HTTP, MQTT, gRPC) enabling request-response, publish-subscribe, and stream messaging patterns with support for JSON and Protobuf serializations. This enables efficient message exchange between the storage nodes, IoT sensor gateways, and consumer applications. The data model of the messages is based on Sensor Measurements List (SenML)[2] specification, a simple and representative format enabling serialization of sensor data even on devices with very limited capabilities. The HTTP APIs are protected from external access by means of Bearer Tokens obtained from an Identity Provider using OAuth 2.0 flows; the MQTT API is protected by the MQTT broker; and the gRPC access control is work in progress. This component is being developed as part of the LinkSmart platform, and

[1] https://bimerr.fit.fraunhofer.de/

[2] https://tools.ietf.org/html/rfc8428

available as open source[3]. The documentation including deployment instructions and API specifications are available publicly.

The initial stable version has been deployed on the middleware cloud instance since M15 and has been used for testing and validation by relevant partners. This instance acts as the storage node for archiving non-personal, aggregated and anonymized residential sensor data for use by other BIMERR applications. Another instance of the storage component will be deployed in the CONKAT pre-validation site as soon as the sensor installation is over. For the KRIPIS pre-validation site, a local storage by BIMERR is not required, since the site already includes infrastructure for local data storage. A number of other instances will be deployed in pilot sites in each apartment and possible on central gateways of each building depending on the network topology and data privacy requirements.

Thing Directory

The Thing Directory is the registry of BIMERR devices such as gateways, sensors, and actuators. The registry acts as a central information point for other applications to discover available devices and the meta data necessary to communicate with them or the corresponding storage endpoints. Among standards for describing devices, the W3C Web of Things (WoT)[4] was selected as the most appropriate. The WoT's Thing Descriptions are proven data models to describe devices such as those which BIMERR uses for residential profiling. We implemented a directory service for Thing Descriptions which is now open source and available as the LinkSmart Thing Directory[5]. This service exposes a RESTful API over HTTP with endpoints to manage resources, as well as to search for particular ones, based on their properties. The API is stable but the specifications are not yet final as we work toward standardization of Thing Description directory API as part of the W3C WoT Working Group. The endpoints are secured and access is allowed to requests carrying a valid Bearer Token obtained from an Identity Provider following an OAuth 2.0 flow.

[3] https://github.com/linksmart/historical-datastore

[4] https://www.w3.org/WoT/

[5] https://github.com/linksmart/thing-directory

This component has been available on the middleware cloud instance since M15 and acts as the central registry for BIMERR residential profiling devices. The collection of all device meta data from KRIPIS pre-validation site is currently in progress.

Node-RED as Gateway Router and Data Processor

Node-RED[6] is an open source even-driven low code programming tool. We utilize Node-RED to implement data routing, transformation, and system mediation. The overall role of this component is two folds. First, it is for integrating sensors controllers with the storage component instances deployed on the local gateways. Second, it is for implementing aggregation and anonymization processes on stored data. We implemented data routing and simple transformation logic using various internal tools and scripts within Node-RED. In particular, the routing and transformation involves retrieval of sensor meta data from Thing Directory, serializing to SenML format, and submitting to the Historical Datastore. The more complex logic such as aggregation of large amounts of data, anonymization, feature extraction, and cleansing are offloaded to a Python-based local server written on top of the TensorFlow[7] machine learning platform.

As of M16, the logic for reading from the Thing Directory has been implemented, routing the data collected using simulated sensors, transforming them to SenML, and forwarding them to the cloud instance of Historical Datastore. The routing and transformation of the data from KRIPIS pre-validation site is currently under development. Instances of the data processor will be deployed on gateways to perform routing and transformation locally on devices.

Keycloak OpenID Connect Identity Provider

An Identity Provider was envisioned as part of the BIMERR architecture, as a central database of users and application data. This information is needed by components of BIMERR, mainly the Building Information Secure Provisioning (BISP) to perform appropriate authorization checks on requests initiated by authentic users and applications. Even though the Identity Provider was originally a part of BIM Management Platform, it was later on moved to the

[6] https://nodered.org/

[7] https://www.tensorflow.org/

middleware for separation of concern and for better positioning inside the architecture. To realize the Identity Provider, Keycloak is utilized, an open source identity and access management solution. It offers single-sign on capabilities and a range of standard protocols for authentication of users and applications. Keycloak provides a rich management UI, as well as interfaces for user authentication. We intend to use Keycloak's directory structure for the BIMERR use cases like it is shown in Table 5.

Table 5 Keycloack's directory structure for BIMERR use cases

Keycloak Attribute	BIMERR Attribute	Example
User	Data provider/consumer	Jane Doe
Group	Renovation project	KRIPIS
Role	User role	Architect
Client	Application	BICA

We selected the OpenID Connect protocol for user authentication and secure exchange of profiles among users and applications. Users must follow an OAuth 2.0 flow (e.g. Authorization Code) to authenticate before accessing a BIMERR application. With user's consent, the application is granted access to the user's profile and performs the necessary steps to ensure the authenticity of user profile (given as a JWT ID Token) and decide (based on internal or external policies) if the request should be served. Similarly, applications which need to communicate with a second application must authenticate but using the OAuth 2.0 Client Credentials flow. In this flow, the second application receives a profile (given as JWT Access Token) and decides if the request should be accepted. Documentation of various authentication flows and security best practices, along with instructions to interface with Keycloak are available internally for BIMERR application developers.

An instance of Keycloak has been deployed on a cloud VM (as part of FIT infrastructure), configured and available since M17. Keycloak was deployed separately from other middleware components for additional security. The instance offers public user sign-up, but user attributes necessary for access control can only be set by privileges users.

1.4.2.3 DIGITAL BUILDING MODEL CREATION TOOLS

The Digital Building Model Creation Tools are a set of front and back-end applications and systems that allow multiple different actors within the building renovation process to survey, create, manage and view digital models of a building prior, in simulation and during the

renovation process. They are used for the generation of enhanced digital models of existing buildings that go beyond geometrical information to also encapsulate information about building equipment, energy usage, resident-dependent building operation, urban geography/ topology, etc. through a combination of improvements of existing scanning-based tools and the introduction of innovative solutions for enhancing models with the use of smartphone apps and Augmented Reality technologies by residents or AEC professionals.

Scan-to-BIM

The Scan-to-BIM Tool is the first tool to be used within the BIMERR process pipeline. The Tool takes as input reality capture data from a building (i.e. laser scans and images) and output a Building Information Model (BIM) in IFC format containing the geometry and material content of all `structural' components (i.e. walls, floors, ceilings, doors and windows) and as much information as possible concerning MEP components (e.g. switches, sockets, radiators, air conditioning units). The output model must contain all the information required by the RenoDSS Tool.

The development of the Scan-to-BIM Tool is seeing progress on three fronts: (1) the Scan+BIM software framework; (2) the Scan-to-BIM (Structural) algorithm; and (3) the Scan-to-BIM (MEP) algorithm. These are detailed in the following.

Early in the project the UEDIN team identified a need to develop an open software platform that is able to handle both reality capture data – in particular point clouds and images – as well as BIM data, with all this data in open formats (e.g. e57 for reality capture data and IFC for BIM data). While this activity was not explicitly defined in the DoA, it was found critical and received attention. Following a review of possible solutions (reported in a conference paper submitted to ISARC 2020), the UEDIN team selected to build a solution based on the Open Infra Platform (OIP)[8, 9]] and xBIM library[10]. OIP provides a software framework and user

[8] H. Hetch and S. Jaud. TUM OpenInfraPlatform: The Open-Source BIM Visualisation Software. In 31. Forum Bauinformatik, Berlin, Germany, 2019.

[9] https://www.cms.bgu.tum.de/en/17-research-projects/46-open-infra-platform

[10] S. Lockley, C. Benghi, and M. Černý. Xbim.Essentials: A library for interoperable building information applications. The Journal of Open Source Software, 2(20):473, 2017. doi:10.21105/joss.0047

interface for loading and navigating BIM data in IFC formats as well as reality capture data (through the use of the CloudCompare library). The xBIM library is used solely for the generation of IFC models outputted by the Scan-to-BIM algorithm. We report that the Scan+BIM framework is approximately 60% complete. It enables loading point clouds and IFC models. The missing components principally include: some data navigation functionalities; object selection and property editing functionalities; and an IO plugin for importing photogrammetric data (i.e. point cloud, images and image calibration matrices) employed by UEDIN's Scan-to-BIM (MEP) algorithm.

Scan-to-BIM (Structural) algorithm: the algorithm shall detect structural components (i.e. walls, floors, ceilings, doors and windows) in laser scanned point clouds and then models the environment in IFC format. Our current V1 algorithm detects walls, floors and ceiling in standard basic environment (like most common dwellings). The algorithm does not detect openings yet. Regarding environment modelling, the algorithm currently outputs an IFC file that contains the above components as well as the 2LSB representation of that environment (required for energy analysis) and ifcSpace objects delimiting each room (required for efficient data handling and localisation for ARIBFA).

Scan-to-BIM (MEP) algorithm: the algorithm detects relevant MEP components in photos of the environment (normal or 360 images, aligned with the laser scanned point cloud by aligning the point cloud obtained through photogrammetric reconstruction from those images). UEDIN reported results on sockets, switches and radiators using both 360 and normal images. We use deep learning Faster R-CNN frameworks, and the performance currently achieved is summarised in Table 21 (Section 2.5.2.2).

Augmented Reality enabled In-situ Building Feature Annotation (ARIBFA)

The work regarding the design and development of the ARIBFA app began on M12 by shifting focus to Microsoft Hololens. The initial work involved research on the SotA on the following topics:

- BIM Model Visualisation and Registration;
- RGB-D cameras use for localization, registration and mapping;

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https://github.com/xBimTeam/XbimEssentials

- IoT network streams integration for hybrid localization and AR annotation.

After the SotA analysis, the next steps in the ARIBFA development effort began with the development of an initial localization, registration and tracking system. The results of our approach show great promise already, using the integrated spatial mapping capabilities of the Hololens device. The initial registration of our system relies on image target acquisition and then continues tracking based on geometric feature mapping. An early result of the efforts in this sub-module can be seen in Figure 4 below.

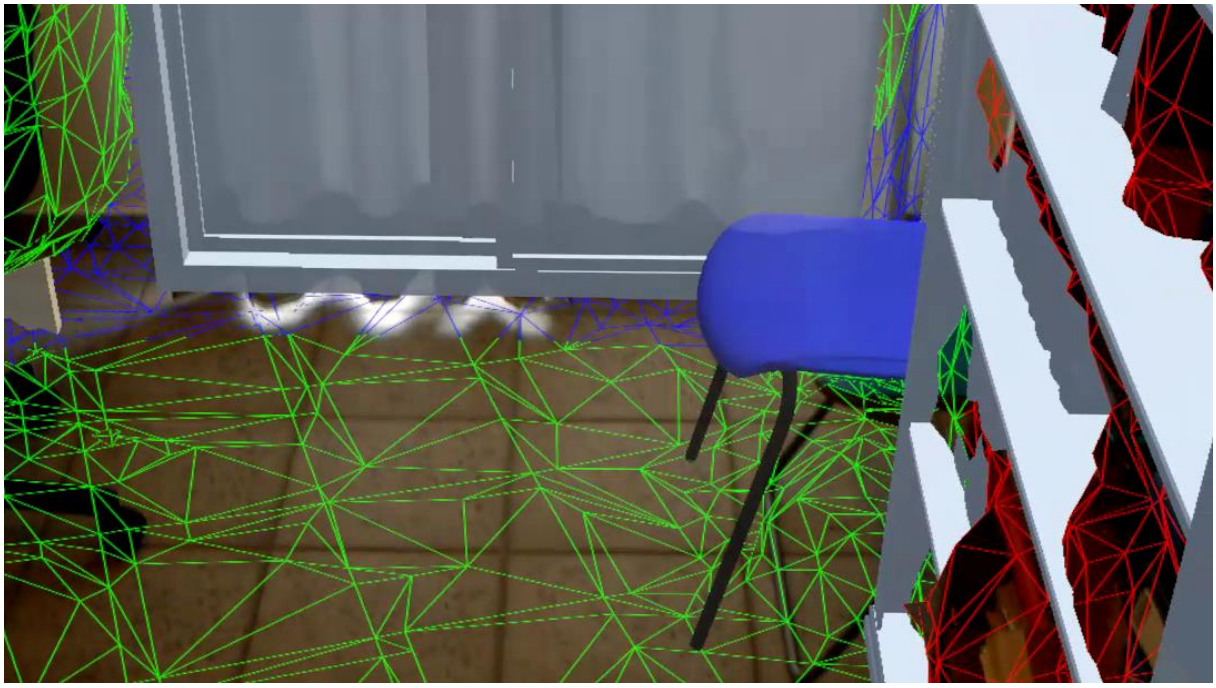


Figure 4: Real-time 3D Model registration on Hololens AR HMD

At the same time, work began on the visualization of BIM models in IFC format within the Unity3D rendering engine. The problem with visualizing IFC models on real-time rendering engines is that BIM models are parametrically defined whereas real-time rendering requires polygon-based models. Several open-source solutions were identified and tested, however none provided 100% accurate visualization and/or mapping to IFC component parameters. The best of these involves the use of the ifCOpenShell library and was adopted and currently under heavy modification through the creation of custom data structure for better 3D visualization and better mapping of object data to its geometry (Figure 5).

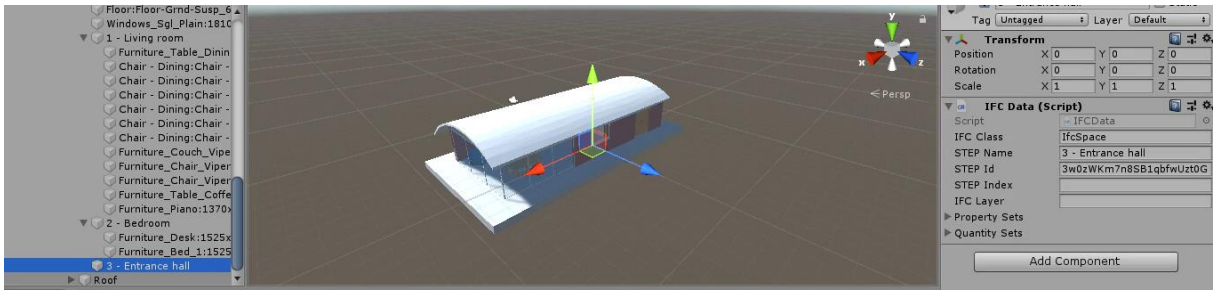


Figure 5: BIM Model visualization in Unity3D

The third sub-module under heavy development since M12 is the AR annotation of objects within a BIM model in real-time. To that end, a system using Yolo as a real-time object recognition library is under investigation and implementation on the Hololens device with support from an external processing server. Finally, work has begun on the design of a multimodal AR UI to complement the sub-modules above in a standalone AR application (Figure 6).

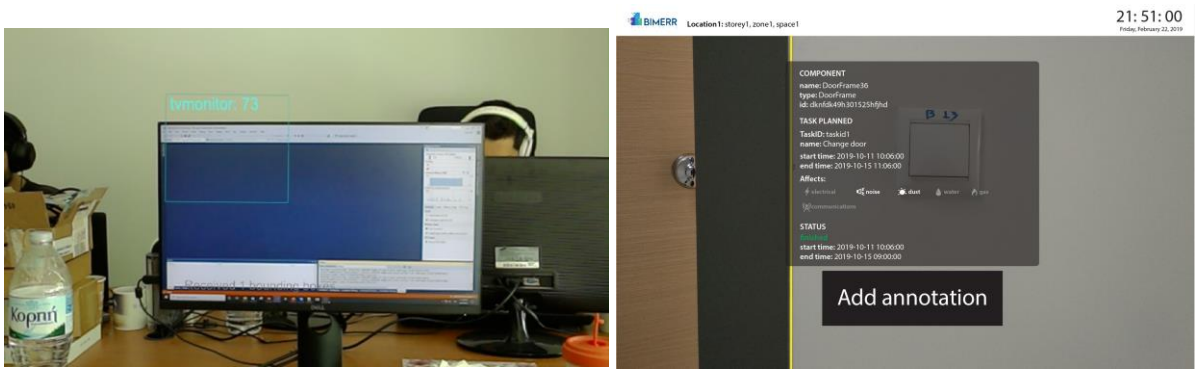


Figure 6: Object recognition and UI design early results

Profiling Resident Usage of Building System (PRUBS)

The PRUBS component aims at designing occupant behaviour models that could act as predictors of occupants' presence, needs (in terms of comfort) and actions. In an effort to reduce the gap between simulated and measured energy performance, these models are used to enrich the energy data models with relevant information to be later transformed as input to the Building Energy Performance Estimation (BEPE) module. Hence, PRUBS addresses the profiling of how the building and its systems are used by the residents. The required information to extract preference and usage models is represented as streams and collected

from a Wireless Sensor Network (WSN) installed at the renovation site and nearby weather stations. During the first reporting period, two main tasks have been running in parallel to streamline and expedite the first version of the building resident energy related behaviour profiling framework's design and delivery (D5.7 to be issued on M22). These tasks and the pertinent objectives that have been achieved due M18 are summarized below:

Task1 – Wireless Sensor Network Design and Installation: An installation management plan, that consists of pre-installation and installation steps, has been sketched to ensure a smooth equipment installation process. Among the pre-installation steps, (1) the definition of PRUBS functional and input data requirements, (2) the preparation of the pilot site audit questionnaire, (3) the pilot site audits and reports, (3) the selection of IoT sensing and metering devices that meet the PRUBS input data requirements, and (4) the Wireless Sensor Topology definition and respective installation guidelines documentation have been completed due M18.

Task2 – Design and development of PRUBS component; algorithmic approach and definition of the occupant behaviour data model: A survey on existing Machine Learning algorithms and data models frequently used for occupant behaviour data extraction and representation has been performed. Candidate algorithms have been applied and tested on existing IoT data streams acquired by a WSN similar to the one that task1 has introduced. For the occupant thermal comfort modelling, the Gaussian Naïve Bayes method has been implemented, a supervised Machine Learning (ML) algorithm that follows the Bayes' theorem assuming conditional independence between the features. To generate meaningful training events/datasets, requested by the aforementioned algorithm, certain pre-processing rules have been defined and programmed to be applied to sensed/metering data provided by the IoT streams data model (SenML). ObXML, an occupant behaviour data model and its XSD schema definition, outcome of IEA-EBC Annex 66, have been analysed and selected as the output data model of PRUBS that includes data about the occupants' preferences and can be formulated as closed-form equations or as data-series so that they are compatible with the BEP module requirements. The design and development of a data transformation component that processes the Gaussian Naïve Bayes method results to automatically generate the obXML file is in progress.

BIM Management Platform

The purpose of the BIM Management Platform is to provide BIM model functionalities covering the following features:

- BIM Model Management/Storage/Versioning
- BIM Model Query System
- BIM Model Comparison
- BIM Model Merging
- BIM Model Validation
- WebGUI/BIM Model Visualisation

Due to EXERGY's exit from the project the work performed with respect to this outcome was limited to the architectural outline of the module as part of the work carried out in T3.5 but also through extensive WP4, WP5 and WP6 discussions throughout the period, to define what the key functionalities as outlined above would entail, how they would be developed and how the platform would connect to providers and consumers of BIM model data and to the BIF as well.

As explained in more detail in Section 2.5.2.2, EXERGY has been replaced by UCL at the beginning of M18, and therefore the progress in the actual development of the platform has been delayed but is now back on track.

Building Information Collection Application (BICA)

The Building Information Collection Application (BICA) aims at providing to the AEC stakeholders a user-friendly mechanism to effectively collect building information from the residents of a renovation site. Such information reported through BICA is considered as instrumental for the renovation design as it can be used to quickly diagnose problems and identify opportunities for renovation/retrofitting interventions that eventually lead to significant improvements in energy consumption and indoor comfort/health conditions. In this context, the intended use of BICA is practically focused on the design activities of a renovation project, prior to any actual renovation works.

Through its mobile interface, BICA displays the spaces in each resident's apartment based on their intended use (e.g. living room, kitchen, bedroom, etc.) and enables the direct collection from the residents, of any potentially missing Building Information Model information, such as operational usage patterns and details about the building equipment, e.g. heating/cooling,

ventilation, domestic hot water and lighting systems as well as white goods and appliances that are placed within a space. In addition, the residents are able to communicate through the BICA app any building weak points that have come to their attention and that the renovation teams should be aware of. Such issues are associated with the overall building or their own spaces (e.g. envelope problems, inefficient windows/glazing or insulation underperformance leading to excessive heat loss, excessive cost/ energy consumption for heating or cooling, etc.) and may be accompanied by complementary information, such as notes and photos. At any moment, the residents may have an overview of their reports along their status in a report log. Finally, the residents access the BICA app to provide information regarding their comfort status at various environmental conditions (e.g. temperature), but also their preferred use of the spaces and components. They may set upper and lower comfort boundaries regarding temperature humidity and illuminance in a 5-level scale, for example, and update them in case they deviate from their actual experience. It needs to be noted that as an apartment may be inhabited by more than one resident, BICA allows all residents to access the same apartment.

In the overall BIMERR picture, BICA interacts with the BIF as a data consumer to retrieve the building information and acts as a data provider for residents' building information, such as building equipment and installed components' information, weak points' reports and feedback on comfort status. With the help of the BIF, other BIMERR applications practically obtain access to the BICA data, e.g. the PRUBS app retrieves the residents' comfort status. BICA also retrieves from the Middleware the sensor data of a particular room.

As per DoA, the Building Information Collection Application (BICA) will be designed and delivered in 2 iterations, with a preliminary version expected on M22 and a final version released on M30. In the first reporting period, the activities related to BICA focused on the design, specification and early mockup prototyping of the intended functionalities.

1.4.2.4 RENOVATION DECISION SUPPORT SYSTEM (RENODSS)

The Renovation Decision Support System (RenoDSS) aims to become a necessary Computer-Aided Design companion of the renovation designer and end beneficiary (e.g. building owner or operator). It generates renovation scenarios and simultaneously quantifies and cumulatively assesses the impact of energy efficiency related renovation measures (e.g. envelope elements, insulation materials) on the building's economic, energy and

sustainability metrics so as to provide to the user a holistic and long-term view on the impact of each renovation scenario. By taking into account the actual (as-is) building characteristics, information about its installed equipment as well as information about connections to utility networks and interaction with other buildings, RenoDSS aims to improve on the accuracy of estimations and projections compared to conventional tools.

Building Material and Components Database

The BIMERR Material and Component Database is an integral part of the BIMERR framework as it provides technical, financial and environmental impact data for building materials and components to BIMERR applications.

The data is sourced from third party providers (technical and environmental impact data) and users (financial data). The BIMERR material data model harmonizes and integrates the data sources and provides a standardized data view for BIMERR applications. The following approach has been followed for creating this initial version of the database:

1. Development of building material classification tree;
2. Identification of third-party data sources which provided the data required by BIMERR applications (based on the results of the BIMERR requirements analysis);
3. Development of a BIMERR material data model which integrates the identified data sources;
4. Extraction of third-party data, normalization and integration according to BIMERR material data model; and
5. Mapping the materials to the classification tree developed in Step 1.

The following data sources are currently used and described in more detail within Section 2.4:

- Baubook for technical building material data;
- Ökobaudat for environmental impact data
- ASHRAE for technical building material data which is not provided by Baubook but required to run energy simulations with EnergyPlus; and
- User input for project-specific financial data.

Aligned with the BIMERR architecture, the BIMERR Material and Component Database can be accessed via REST endpoint by BIMERR applications. The following data can be retrieved

from the endpoint: (i) get timestamp of the latest database update, (ii) get full list of materials without material details, (iii) get full list of materials with material details, and (iv) get material details of given material.

Xylem started the work on T7.1 (Building Material and Component Databases) in December 2019 when it was clear that Exergy will leave the project.

Renovation LCA/LCC Module

The BIMERR LCA/LCC module provides information about the financial and sustainability impact of the renovation scenario under investigation. Cost is usually one of the most critical parameters in deciding whether to proceed with the renovation effort and needs to be seen on a long-term horizon to properly aid decision making. The LCA/LCC module takes project-specific purchasing, installation, and maintenance costs of renovation measures into account. It also aims at accurately estimating yearly energy cost savings based on potential renovation measures and the increased energy efficiency figures which are provided by the BIMERR Building Energy Performance module. Besides costs, the LCA/LCC module provides sustainability KPIs to estimate and compare the overall sustainability impact of potential renovation scenarios.

Until M18 we (i) completed the LCA/LCC method research, (ii) defined economic and sustainability KPIs, (iii) implemented the renovation measure data model, and (iv) integrated the xBim library into RenoDSS to extract required IFC data. In alignment with the content of D3.3, certain economic and sustainability KPIs have been identified to be calculated by the LCA/LCC module.

The necessary input data to calculate economic and sustainability KPIs is obtained from the BIMERR Material and Component Database (which currently contains sustainability data for building materials from the Baubook database) and project-specific financial data provided by the user.

Building Energy Performance Modelling Module

Within BIMERR, Industry Foundation Classes (IFC) files are used to streamline and expedite the collection of the building static information (building elements, materials and their thermal properties, HVAC components, to name but a few), while obXML files capture the

dynamic data (schedules and thermal comfort preferences). A survey on existing BEP calculation methodologies that exploit both IFC and obXML data to automate the BEP models' generation has been performed, concluding to EnergyPlus as the BEP simulation engine to be used within BIMERR.

Beyond a wide variety of EnergyPlus output parameters, specific variables can be reported based on the actual simulation problem described in the EnergyPlus Input Data File (IDF). The Report Data Dictionary (RDD) of EnergyPlus is a text file listing those variables for reporting during the simulation of a certain IDF. The energy KPIs that have been documented in D3.3 and the RDD file generated by a baseline simulation have been analysed to define the energy KPIs that need to and can be calculated by the BEP module. Results stemmed from the aforementioned analysis have been further processed to determine the BEP data requirements towards calculating the requested energy KPIs.

In addition, the first version of the BEP module protype has been designed and developed, consisting of three main sub-components: IDF generator; BEP simulation; and BEP Manager. In alignment with the BIMERR architecture (D3.5), these sub-components collaborate to address the BEP module's scope. In summary, the BEP Manager, acts as the orchestrator of the BEP module. It receives scenarios evaluation requests from RenoDSS and triggers the IDF Generator. The IDF generator, collecting the building static (IFC), dynamic (obXML) and weather (EPW) data, processes the content of the IFC file to generate the Input Data File of EnergyPlus simulation engine, while the co-simulation with the obXML, to take into account actual schedules based on data-driven occupant behaviour models, is established, and submits a simulation request to the BEP simulation module. When the simulation is completed, outputs/report files are populated and sent to the BEP Manager to be further processed and populate a Json file with the KPIs that are sent back the RenoDSS. An initial version of interfaces has been released to start experimenting with the RenoDSS and the BEP module data exchange.

Urban Planning Module

The BIMERR Urban Planning provides the geographical perspective of the building under renovation and its surrounding buildings based on the geolocation extracted from the building's IFC file. The map view will allow to set energy production and consumption profiles of surrounding buildings. Based on these profiles the urban planning module will calculate

electrical energy excess profiles of the surrounding buildings to estimate how much electrical energy excess is available to the building. Based on the BIMERR BEP module output, the urban planning module will estimate how much energy generated in the building-level can be exported to the district-level.

Until M18 we assessed the urban planning data model requirements and implemented the map view for the building and its surrounding buildings.

Decision Support System Engine and UI & Module Integration

The main aim is to put forward an intuitive and easy-to-use interface that illustrates the renovation options, evaluates their impact on the building performance and guides the user through various alternatives towards the optimal choice for given boundary constraints (such as size of intervention, budget, target energy savings, etc.). RenoDSS will offer to the user a renovation configurator that will allow for exploration of alternative renovation interventions.

Until M18 we completed the RenoDSS UI design, set up the RenoDSS infrastructure and system, implemented the BEP module (T7.3) communication, completed the RenoDSS projects UI view, started the RenoDSS building UI view, started the RenoDSS scenario UI view, and completed the RenoDSS renovation measures admin UI view. The current development status is deployed and available at https://renodss.xylem-technologies.com. For security reasons, only authorized IP addresses can access the service. RenoDSS credentials can be requested by sending an email to info@xylem.tech.

1.4.2.5 PROCESS & WORKFLOW MODELLING AND AUTOMATION TOOLKIT (PWMA)

The Process & Workflow Modelling and Automation toolkit (PWMA) enables the creation of a digital twin (DT) about the renovation process, in order to apply analysis, simulation and monitoring of the renovation process on the one side, as well to support pro-actively the renovation process by stimulating the real-world processes using adaptive workflows. The interaction of this DT with the real-world is established via knowledge extraction from domain expert while modelling the renovation process, by tool invocation and data exchange performed by the executing adaptive workflow engine as well as end user and resident's interaction via mobile apps. The first iteration will conclude mainly in M19 with the deliverables D6.1, D6.2, D6.4 as well as with D6.6, D6.8 and D6.10.

The second iteration will apply a concrete DT for the use case, enrich the functional capabilities of the DT as well as demonstrate and adapt the interconnection with supporting tools. The tasks and the current and planned iteration are elaborated in the following sub-sections.

Adaptive Renovation Process & Workflow Models

As described above, after the first iteration in D6.2 "Adaptive Renovation Process & Workflow Model 1", modelling of renovation processes is used to introduce a process-oriented structure into the BIM tools and data with the goal to enable a process-oriented simulation, execution and monitoring to manage costs and times of renovation projects. We apply the well-established Plan-Do-Check-Act framework by introducing a **design phase** (Plan), an **execution phase** (Do), a **monitoring phase** (Check) as well as a **reflection and improvement** phase (Act), in order to provide a decision support environment for renovation project managers.

The renovation process **design phase** and its corresponding tools enable the design, the analysis, the formal verification, the documentation and the transformation into executable formats of renovation processes. We propose to use standard BPMN notation. We consider renovation process templates for thermal insulation in form of (a) Facade improvement outside, (b) Facade improvement inside, (c) Roof improvement outside, (d) Roof improvement inside, (e) Window exchange. Those templates are then transformed into processes for a concrete renovation project and if needed also transformed into an executable workflow.

The renovation process **execution and monitoring phase** with its corresponding tools support the execution of a renovation process - which is still executed manually on the construction site - with monitoring, simulation and workflow execution tools. The monitoring displays KPIs in form of actual and via simulation predicted time and costs. The knowledge for cost and time prediction is iteratively improved, when creating a digital twin with extended log-files from a workflow engine. Relevant personal, material and machine-rental costs as well as execution and duration times are continuously monitored and predicted.

The **reflection phase** and its corresponding tools support the collaborative reflection of a renovation project. Collaborative platforms enable comments on the decisions taken during

the renovation process as well as enable the evolution of the extracted knowledge. The workflow engine creates a digital twin of the renovation process to enable process mining.

The outlook for the next period in this task is (a) lifting the process design to full-fletched modelling, (b) introducing artificial intelligence, (c) enriching the digital twin of the process, and (d) raising the interconnection with other BIM tools.

Renovation Process Simulation tool

As described in the first iteration of D6.4 "Renovation Process Simulation Tool 1", the provided renovation process management environment has two types of flexibility to enable configuration and adaptation. First, we use the meta modelling platform ADOxx that enables the configuration of process modelling, KPI modelling and Data modelling notation by providing a full-fledged process model repository. The repository uses conceptual meta models for the particular needs of BIMERR and aligned the concept with the BIMERR ontology. This semantic alignment enables the seamless use of data that come from other BIMERR applications. Second, to provide features, services and tools for the ecosystem around the process management platform, we used the Microservice framework OLIVE to provide:

- features like (a) the knowledge-based simulation of renovation processes, (b) the dashboard visualization of renovation process status, (c) the co-creative reflection of the renovation process using XWIKI and generating pages from models and feedback comments from the pages into the models.
- connectors to third party tools like (a) to export process models for execution to a workflow engine, (b) to import data from the BIMERR integration framework that are display the status of the renovation process, (c) to interact with Process Mining tool that analysis the process execution after the renovation process has been complete in order to create lessons learned for the next project.

The next iteration will adapt the tool set to provide better support for the renovation process management as well as to better integrate 3rd party tools into the updated renovation process management ecosystem.

Adaptive Workflow Management and Automation tool

The purpose of the adaptive workflow management tool is to orchestrate the renovation tasks and facilitate information exchange between them. It will further enable stakeholders to keep track of the entire process at real-time as well as automated reporting and adaptation of the workflow in case of planned or unforeseen developments during the renovation process. Adaptiveness is necessary to account for unexpected effects, such as weather patterns that may prohibit specific works or worker unavailability due to sickness, etc.

In the first reporting period, the requirements of the stakeholders have been collected and the specifications of the tool have been defined. The first version of the tool has been implemented, which allows for the project manager to interact with the reconstruction process, to delegate sub-tasks for workers and foremen, to follow the KPIs and to mark Health and Safety issues related to tasks.

The component works with the reconstruction process model, which is imported in the form of a BPMN-DI model coming from the modelling tool. Several process models can be imported and used by the project manager as main or sub-process. The tool allows also to define own processes, which can be later instantiated to workorders, which represent real work to be delivered.

Both, the main and sub-workorders can be executed and monitored via web interface, or via the application for on-site worker support (see below).

Data imported from the BPMN-DI model as well as the data created by the project manager, foreman and workers are made available via several JSON structures to be used by other components. The two main webservice endpoints providing outputs implemented are 1) the list of real instances created from specific reconstruction process model and 2) detailed data about particular instance of the process.

Smart glass application for on-site renovation worker support

The app for construction workers (applications for smart-glasses) aims to provide in-the-field guidance on several fronts: e.g. to alert them to hazardous components, assist them in reporting work progress (which will be automatically synchronized across BIMERR tools to provide all stakeholders an up-to-date view on activities and actual progress), guide them in the process of installation/assembly based on vendor information, etc. This tool is based on the I3D platform of NT which is adapted accordingly.

In the first reporting period, the requirements of the stakeholders have been collected and the specifications of the tool have been defined. The application can be used not only by the workers, but also by foreman and project manager to interact with the reconstruction processes and tasks assigned to them.

The application allows to display the list of workorders-tasks assigned to the user. The user can interact with the task and report the progress including multimedia attachments as part of the workorder report. The backend of the application is fully integrated with the Adaptive Workflow Management and Automation tool, so the changes made by the project manager are instantly reflected in the application, including indicated safety hazards or adjustments made in the process.

Renovation progress monitoring & alerting application for residents

Since the work on the Renovation progress monitoring and alerting application for residents started on M14, the main outcomes for this period involve the technical and functional requirements definition for the mobile application based on the use cases defined in T3.1, the preliminary design of the user interface and interaction based on the identified requirements, and the coordination among this and other tasks involving end-user oriented UIs so that the look and feel of the application is consistent among all BIMERR UIs.

Furthermore, preliminary work has begun to integrate the back-end functionalities of the PWMA toolkit, in order to provide user notifications for health and safety issues arising from tasks scheduled in the vicinity of the user, monitoring progress based on real-time project updates and to provide feedback from the user regarding issues pertaining to specific task implementation in the building. In Figure 7, a first rendering of the application UI is depicted:

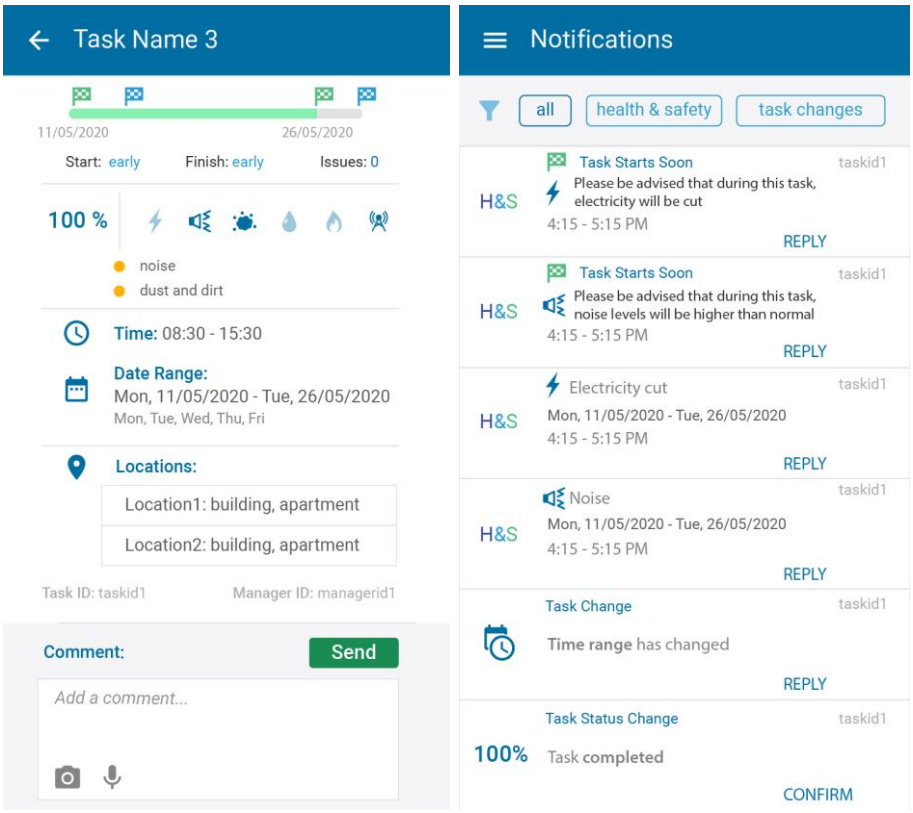


Figure 7: PWMA App for Residents UI

1.4.2.6 BIMERR INTEROPERABILITY FRAMEWORK

The BIMERR Interoperability Framework (BIF) aims at addressing semantic interoperability challenges among the BIMERR tools and components, as well as with third-party legacy ICT systems to enable seamless building information management and effortless data exchange among the different AEC stakeholders who are involved throughout the renovation process of existing buildings, from project conception to delivery. During the 1st reporting period, the BIF activities (in WP4) have culminated as planned with the initial release of the integrated BIF along with its 4 sub-components, namely the Building Information Collection & Enrichment Component (BICE), the Building Semantic Modelling Component (BSM), the Building Information Query Builder Component (BIQB) and the Building Information Secure Provisioning Component (BISP), that are described in detail in the following paragraphs.

Building Information Collection & Enrichment

The BIMERR Information Collection & Enrichment Component (BICE) aims at timely and effectively collecting building-related data from multiple sources, ranging from the BIMERR

applications and middleware to legacy systems, while effectively addressing a number of semantic and syntactic interoperability challenges from a data management perspective. In essence, BICE plays an instrumental role from the perspective of the building-related data providers as it is practically responsible for: collecting building-related data in multiple modalities, processing them according to the provisions of the relevant BIMERR data models (that are aligned with the BIMERR ontologies), and finally storing and indexing the transformed data along with their accompanying information so as to be eventually available to all authorized BIMERR applications (by the BISP). As documented in the BIMERR Deliverable D4.6, BICE consists of five subcomponents, namely the Data Handler, the Data Storage & Indexing, the Data Ingester & Fetcher, the Master Controller and the Knowledge Graph Generator; each one designed with a distinct role, a distinct scope and a distinct set of core functionalities.

From a user-driven perspective, the BIMERR Information Collection & Enrichment Component allows for the definition of data collection jobs by the BIMERR application owners/developers. At preparation time, the configuration of the data collection job needs to successfully be created and stored. At execution time, the *Data Ingester & Fetcher* is triggered by the *Master Controller* that provides the configuration file of the data collection job that is to be executed in order to successfully retrieve the building data that are uploaded either directly by users or indirectly through APIs. APIs may be provided by the BIMERR applications for application data and from the Middleware in the case of streaming sensor data. Additionally, the Data Ingester & Fetcher allows for import of open data that may come from various external open data sources by providing the necessary mechanisms to connect and retrieve the corresponding datasets based on the provided configuration. The Master Controller then triggers the *Data Handler* passing through the corresponding configuration file in order to execute all the necessary mapping instructions and transformation rules (e.g. for datetime format transformations, time zone transformations and measurement unit transformations) and ensure that the underlying data are compliant with the respective BIMERR data model. The Data Handler is also responsible for preparing the requested data for export in collaboration with the BIF Building Information Secure Provisioning component. Once the data handling processes are completed in the Data Handler, the *Data Storage & Indexing* subcomponent is initiated by the Master Controller to appropriately store the data payload along with its accompanying information in multiple big-data enabled storage modalities, while offering an effective indexing mechanism that facilitates the near real-time

indexing and advanced querying capabilities over the indexed data. Furthermore, open datasets available in the Linked Open Data cloud, as well as open data from the Data Handler (if they do not have any access policies restrictions), are accessed by the *Knowledge Graph Generator*, in order to generate complementary knowledge over the building-related data.

Building Semantic Modelling

The BIMERR Building Semantic Modelling Component (BSM) aims at ensuring the semantic mapping and reconciliation of the building-related data that are to be collected from various sources, ranging from the BIMERR applications to legacy systems, while effectively addressing a number of semantic and syntactic interoperability challenges at data and model levels. The BIMERR Semantic Modelling component is practically responsible for the definition, application and maintenance of the BIMERR ontologies and data models and their proper synchronization, towards ensuring semantic consistency and coherency among the building-related data exchanges within BIMERR and with any other external systems. As documented in the BIMERR Deliverable D4.4, BSM consists of three core subcomponents, namely the Model Mapper, the Model Lifecycle Manager and the Ontology Manager Framework.

From a user-driven perspective, once a data provider has initiated a Data Collection job in the BICE, the *Model Mapper* is involved to undertake the semi-automatic mapping of the source data that are collected and shall be exchanged through the BIF, to the appropriate BIMERR data model. The Model Mapper derives the underlying schema from the available sample, predicts the mappings of the external data concepts to the BIMERR concepts, while enabling users to complement the mapping arrangements and add custom transformation rules. Upon a successfully completed mapping configuration, the Model Mapper populates the "Configuration File" with the data model mapping information which are made available to BICE. In parallel, the *Model Lifecycle Manager* and the *Ontology Manager Framework* act on the background to enable the functionalities of the Model Mapper: On the one hand, the Model Lifecycle Manager imports the basic data models it has received from the Ontology Manager Framework, enriches the data model information (in accordance with the data model information described in the BIMERR Deliverable D4.2), exposes the BIMERR data models to any BIF component that requires them, and manages the evolution of the BIMERR data model in constant communication with the OMF to ensure that the stored data models and ontologies are aligned. On the other hand, the *Ontology Manager Framework* offers a

documentation and publication tool that extracts the ontology metadata and generates the documentation from the relevant ontology metadata properties which is made available to the BIMERR Knowledge Graph and the BIMERR Ontology Repository. In addition, the Ontology Manager Framework provides a JSON serialisation of the ontology to the Model Lifecycle Manager and, in turn, receives the updates from the BIMERR data models that need to be incorporated in the BIMERR ontologies network.

Building Information Query Builder

The BIMERR Building Information Query Builder Component (BIQB) aims at enabling the AEC stakeholders and systems to request the exact building data they need from the BIF, through custom queries, and effectively acquire them (in collaboration with the BISP). The BIQP is practically responsible for the definition, resolution and automatic execution of information queries, towards ensuring semantic consistency and coherency among the building-related data that are retrieved, while removing any unnecessary data "clutter" and complying with the applicable data access policies. As documented in the BIMERR Deliverable D4.8, BIQB consists of three core subcomponents, namely the Data Query Builder, the Model Query Builder and the Query Handler.

From a user-driven perspective, the BIQB allows the users to search for the building data of their interest along a number of parameters through an intuitive interface for faceted search, that indicatively facilitates searching any data for a specific building or searching data with a specific temporal coverage or type (through the *Data Query Builder*), as well as searching specific categories or fields/concepts that should appear on the results (through the *Model Query Builder*). The different parts of the query are decomposed by the *Query Handler* in order to search over the BICE Data Storage & Indexing that includes indices to all available data (along with their metadata). The results acquired for a specific search query are sent to the BISP component to check the applicable access policies defined by the different applications that act as data providers in the BIF. The results which the user is authorized to access are then displayed in the user interface of the Data and Model Query Builder, allowing the users to define which results they need, and how they would like to get access to the data, e.g. as a file or through the BIF APIs while storing the query for quick reference. If the selected acquisition method is through the BIF APIs, the users define which fields/concepts of the available building data they need, configure their preferred method to acquire the data and the query parameters, and test the query results they get with the specific settings. At

any time and once the access policies are dynamically enforced in BISP, the different BIMERR applications are able to retrieve the data of their selection with the specific query id by providing the query parameters and the api key (they have been provided with by the BIF).

Building Information Secure Provisioning

The BIMERR Building Information Secure Provisioning Component (BISP) aims at enabling the AEC stakeholders and systems to dynamically control access over their building-related data in a fine-grained manner, while providing data protection, confidentiality and security to the overall BIF. The BISP is practically responsible for the definition, resolution and enforcement of access policies using Attribute-Based Access Control (ABAC) policies, which allow the data providers (BIMERR applications and third-party systems) to protect and share their data sets, even when they do not have any prior knowledge of the potential individual data consumers in BIF. A proper separation of concerns between policy specification (at data collection time in collaboration with the BICE) and policy enforcement (at data query and access time in collaboration with the BIQB) has been effectively pursued, while arbitrary attributes in policies are dynamically enforced. As documented in the BIMERR Deliverable D4.8, BISP consists of four core subcomponents, namely the Access Policy Management, the Policy Enforcement Business Logic, the Access Request Transformation Handler, and the Attributes Handler.

From a user-driven perspective, the BISP allows the users (i.e. data providers) to define the access policies for a specific dataset they have provided to BIF, e.g. by applying policies for specific users, roles, groups and applications that should have access to their data. Such policies can be revised or cancelled at any time the data providers want through the *Access Policy Management* interface. The definition of such access policies is actually the only direct interaction that the BISP has with the data providers or data consumers in BIF as it generally acts under the hood to enforce the access policies at query time and at retrieval time in collaboration with the BIQB and the BICE. To this end, the *Access Request Transformation Handler* prepares any incoming access request to the internal BISP format while the *Attributes Handler* collects the requested additional attributes which are needed in order to validate an access policy. Subsequently, the reconstructed request, extended by additional attributes, is manipulated in such a way so that the relevant access policies rules are validated by the *Policy Enforcement Business Logic*, which is responsible for handling several access requests and in return provides the response based on the predefined access policies to the BIQB and BICE.

1.4.3 Groundwork on Validation & Evaluation

Validation & Evaluation activities enable the verification of all tools which will be designed and developed in the BIMERR project to support the process of building renovation.

According to the BIMERR DoA, the pre-validation phase consists the first step of the BIMERR tools validation and demonstration which will take place in actual buildings that are not going to be renovated. The intention is to use the BIMERR tools in a context that enables: i) full experimentation with the as-is digital building model creation tools and evaluation by comparing their results with digital models obtained from other sources and in-situ inspection; ii) experimentation with the renovation-support tools using the digital models that will allow their users to assess the applicability to real-life situations, their usability and provide feedback to the development partners for improvements. CERTH and CONKAT provide the pre-validation sites, as it is detailed below.

The validation and evaluation phase will be based on two pilot sites selected within RP1: multi-residential buildings, where in the next two years the process of renovation and thermo-modernization will be carried out and on which the complete validation and demonstration of all tools developed in BIMERR will be possible. Formal issues such as agreements with administrators and tenants' consent to participate in activities were completed.

Despite the fact that, according to the DoA, the activities on selected facilities start after the first reporting period, the consortium partners responsible for the implementation of these works have accelerated the implementation of some works. The details of the pilot buildings and the work carried out in the reporting period is presented in the following sections.

CERTH Pre-validation Site

The KRIPIS Smart Home facility of CERTH was selected as a pre-validation and evaluation test site for BIMERR activities due to its infrastructure that contains a robust IoT framework and a host of sensors and devices that can be used to test different modules and algorithms pertinent to renovation projects. Especially for testing thermal characteristics of the building with respect to occupant behaviour, the KRIPIS pre-validation site provides a 24-hour real-time access to IoT streaming data coming from multiple sources, while historical data has been already accumulated in the past year.

Furthermore, the fact that this facility is a building used daily by CERTH personnel and not a residence makes it an ideal environment whose business processes and use characteristics are well-defined in advance, so that correlation of simulated results of BIMERR components can be easily validated against real-world ground truth.

Although the work plan defined in the DoA initially called for starting the pre-validation activities on M23, the consortium decided to push these activities earlier in order to gather more data within the time available. To that effect, access was provided to all partners that need it to the historical data and to the real-time values of the IoT sensor framework in KRIPIS, while also the design of a BIM model of the building initiated, based on the architectural, electrical and mechanical drawings of the building. Finally, to assist in the efforts of T5.2, a full laser scan of the building took place along with a photo session to be used for photogrammetry.

Figure 8: BIM Model of the KRIPIS Smart Home

CONKAT Pre-validation Site

As a result, according to the DoA a residential building from the portfolio of project partner CONKAT should be selected as pre-validation site. CONKAT has constructed and renovated a number of residential buildings of various types in Greece. Based on the testing needs during project implementation, CONKAT will provide access to buildings whereby audits, surveys and digital model population activities (e.g. scanning and/or walkthroughs using AR glasses) will take place.

Thus, in the framework of the project, CONKAT has selected a building located at the north-east suburbs of Athens. For this building, the user has already agreed to provide access to his apartment for the execution if BIMERR pre-validation activities (including sensors installation and 3d laser scanning), while a consent form has already been signed.

The elevation of the pre-validation building area above the sea level is 185 m, while the latitude and the longitude are 38.021332 and 23.798630. Figure 9 depicts the north-east suburbs of Athens with the building location marked.

Figure 9: An approximation of the CONKAT building site

The CONKAT building is an apartment that belongs to a three-storey dwelling, built in 2000, with three apartments at each floor, and a basement. The selected apartment has a total surface area of 90 m^2 and is on the second floor facing South East. Exterior views of the building are presented in Figure 10, and interior in Figure 11.

Figure 10: CONKAT pre-validation building – exterior views

Figure 11: CONKAT pre-validation building – interior views

A brief summary highlights that the external and internal walls are uninsulated, windows are double glazed, while roof is insulated. The heating system of the building is a central system with an oil boiler and hot water radiators at each room, while the thermal bodies (radiators) are depicted. During winter, the central heating system is available all the time, while an apartment thermostat controls its operation. Additionally, whenever the occupants do not feel thermally comfortable (e.g. the central heating system is not capable to reach the desired temperature) the occupants may "ideally" turn on the A/C split-type units and electric convectors to heat some rooms (where such systems are placed) independently. The cooling of the apartment is available all the time during the summer period. The ideal usage pattern assumes that the occupants turn on the A/C units only when they are present. It is obvious that deviations exist from such "ideal" use cases that are hard to a priori ascertain. Hence, the cooling of the building is exclusively achieved by A/C split units, while supplemental heating is provided by A/C split units and electric convectors.

Currently, no sensors are installed in the CONKAT pre-validation building; the only measured, available data are the electricity consumption data from the analogue meter and the oil consumption data from the heating system. Thus, it has been decided that a Wireless Sensor Network is going to be installed, in the framework of the BIMERR project, to support the project technologies implementation and execute the pre-validation activities. At the same time, a 3d laser scanning was completed during month 18 of the project, after an agreement on the parameters with the technology providers, while the photogrammetry of the pre-validation site is also under execution.

Poland Pilot Site

As shown in Figure 12, the Polish pilot building is located in the central Poland, in the Mazovia region, in the surroundings of the Warsaw, capital of Poland. The address of the building is: 15, Wiarusów Str, 04-290 Warsaw, South Praga.

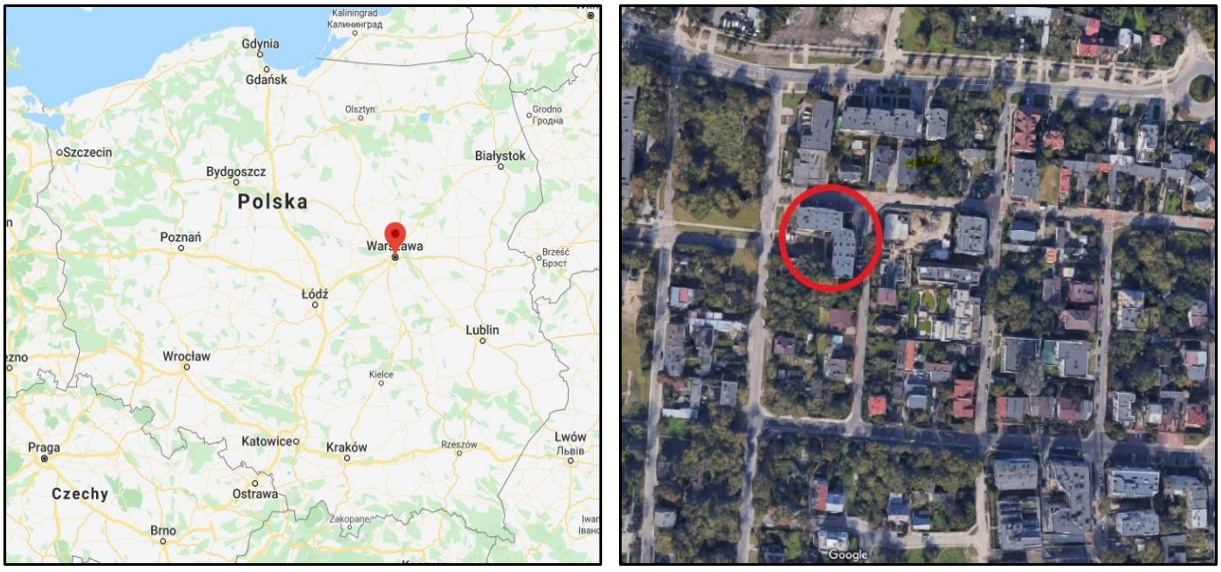
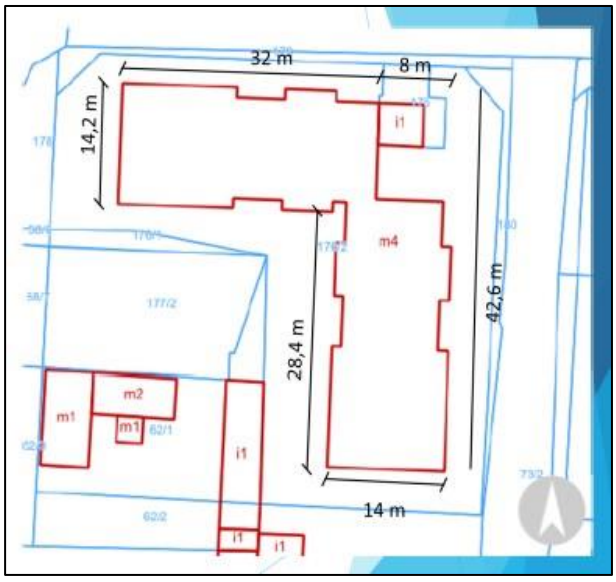


Figure 12 Location of the Polish pilot building

Figure 13 shows the Polish pilot building, built in 1995 in the south Praga district, surrounding of post-industrial buildings. This year, the area of south Praga was newly developed by the city to be a residential buildings' area. The building is owned and managed by the Warsaw City Estates Management Office and is used as a social building providing apartments with low rental costs for families with difficult financial situations.

Figure 13 Pilot building view from the outside

At the end of 2019, Budimex received a letter of intent from the building administrator, which enabled to obtain technical documentation in the first quarter of 2020. Subsequently, it was possible to verify the condition of the building and confirm its suitability for the BIMERR project. Details about the Polish pilot site are presented in Figure 14.



Main building information	
Building area (m^2)	838,40
Net building volume (m^3)	6195,50
Gross heated volume* (m^3)	9394,40
Floor area of apartments (m^2)	2190,20
Floor area of other heated areas (m^2)	288,00
Net heated building area (m^2)	2478,20
Number of staircases	4
Number of floors	4+basement
Floor height (m)	2,3/2,5
Number of tenants	120 (in year 2017)
Number of apartmetns	64
Type of heating	Central heating
SA:V ratio	0,39

Figure 14. Pilot building dimensions and basic information

At the end of April 2020, Budimex signed the agreement with the building administration which enables conducting demonstration work on the pilot building.

At the end of June 2020, Budimex organised physical meetings with building residents during which the BIMERR project was presented and the residents could state questions. At the end of this meeting, the forms regarding the residents' consent to participate were handed out. The forms were collected one week later.

Until 2019, the building was equipped with electric heaters in each apartment, together with electric water boilers which provided domestic hot water in the apartments. In 2019, the entire building underwent a comprehensive central heating and domestic hot water renovation. Since then, both systems are supplied from district heating, which enters the building in the heating node located in the basement. As part of this renovation, new piping was installed in the building together with new radiators and thermostats located on each radiator (one radiator per room including bathroom).

According to the building administrator, there is a complete thermal renovation of the building planned for 2021, excluding the roof, which has already been insulated and modernised few years ago. In the scope of this renovation, the following tasks are planned:

- reparation of existing cracks on the facades of the building,
- removal of the existing (one facade) and installation of the new thermal insulation on all facades according to the EN standards,
- where necessary, small repairs and replacement of the windows will be done

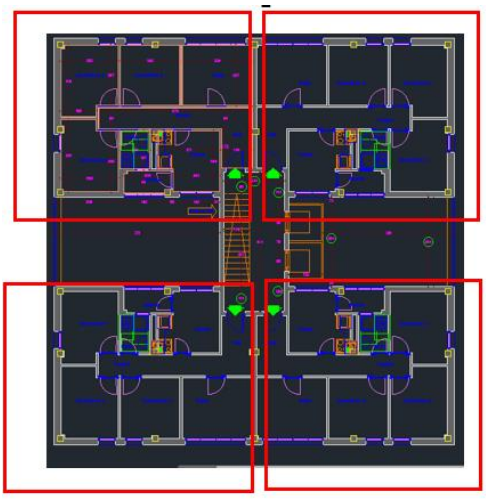
Spain Pilot Site

The Spanish pilot building is located in the North of Spain as shown in Figure 15, in the Basque country, in the surroundings of the industrial city of Bilbao. The exact address of the building is: Larrakoetxe Kalea, 1, 48004 Bilbao.

Figure 15 Location of the building

Figure 16 shows in more detail the Spanish pilot site building which was built in 1960 in the framework of a global urbanistic ensemble, is 15 storeys high: on the ground floor there are 2 homes and 2 commercial premises, and in each of the remaining 14 floors, there are 4 flats (all very similar, each flat has a surface of approximately 59m2, see top view beside) per floor. In total, there are 58 apartments (social housing) and 2 locals. The Building is owned by a social housing administration, which rents the flats, but there are also some residents who owns their apartments (approximately 30%).

A first renovation programme was undertaken between 1982 and 1989 (facades reparation for waterproofing, change of windows, repair of decks and roofs, structural strengthening, construction of a general drainage network and public lighting for the whole neighbourhood). It is noteworthy that this neighbourhood is the corner stone of a larger rehabilitation program called Opengela (2019-2022). Opengela is a European innovation project which looks to spread urban regeneration in the Basque Country, creating neighbourhood offices which provide advice and support to the neighbourhood community. An energy certification has established that the overall energy class of the building is G.



	Surface (m2)
Living room	8.24
Kitchen	6.62
Bathroom	2.15
Bedroom 1	7.56
Bedroom 2	7.54
Bedromm 3	7.02
Corridor	8.61
Loggia	1.99

Figure 16 Exterior view, floor's top view and typical flat's surfaces

The main objective of the renovation measures is an improvement of the energy class, from G to C category. To reach that objective, the 5 main intervention types are following:

- Improvement in thermal insulation
- Improvement of the accessibility
- Improvement of the Air Conditioning System (ACS) and heating installations (Viability study of the incorporation of renewable energies).
- Energy consumption monitoring
- Improvement of fire protection system

Please notice that accessibility and fire protection do not fall under the BIMERR activities.

2. EXPLANATION OF THE WORK CARRIED OUT PER WP

2.1 WP1 - ETHICS REQUIREMENTS

2.1.1 Summary of the WP objectives

The objective of this WP is to ensure compliance with the 'ethics requirements' the project must comply with.

2.1.2 Description of WP work during the Reporting Period

2.1.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

Table 6 WP1 deviations description

Problem Description	Corrective actions undertaken by partners
N/A	N/A

2.1.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

During the first reporting period, the main outcome of WP1 was:

- D1.1 - *H – Requirement No. 1,* led by FIT, is a confidential report presenting the process for identifying and selecting research participants as well as for collecting informed consent from participants. Issues related to the ethical gathering and treatment of data and findings are presented. Information about the identification and recruitment of research participants will be included in the appropriate deliverables related to the user research and validation activities.

2.1.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Task	Partner	Activities performed in this period
	FIT	• Leadership and contribution for D1.1 - H - Requirement No. 1
	BX	• Work on unified consent form
	FER	• Work on unified consent form

2.1.2.4 WP DELIVERABLES

Table 6 reports the status of deliverables foreseen for the work package during the 1st Reporting Period. For each deliverable, title, lead beneficiary, due date and submission date are reported.

Table 7 WP1 deliverables status related to the 1st Reporting Period

Deliverable	Lead	Due	Status
D1.1 - H - Requirement No. 1	FIT	M06	Submitted M06

2.1.2.5 WP MILESTONES

Table 7 reports the status of milestones foreseen (if any) for the work package during the 1st Reporting Period. For each milestone, title, lead beneficiary, due date and status (achieved/not achieved) are reported.

Table 8 WP1 Milestones status related to the 1st Reporting Period

Milestone	Lead	Due	Status
No milestones in RP1	-	-	-

2.1.3 WP Plans for the next Reporting Period

The WP has no activities in the next reporting period.

2.1.4 COVID-19 Impact

WP1 is not affected by the pandemics.

2.2 WP2 - QUALITY ASSURANCE AND PROJECT MANAGEMENT

2.2.1 Summary of the WP objectives

The main objectives of WP2 are to:

1. Ensure the achievement of project goals within time and on budget with the required quality level.

2. Ensure an effective, efficient, and expeditious management of resources as well as efficient communication with all partners and with the Commission, providing on time all deliverables and reports.
3. Perform the overall management of the project and coordination among the different WPs.
4. Establish the communication flow and methods for reporting, monitoring and quality assurance, including innovation and ethics management.
5. Coordinate the reporting to the Commission.
6. Develop measures for avoiding risks regarding financial, legal, administrative and technical co-ordination for overcoming potential risks and to establish contingency plans if needed.

WP2 consists of three tasks which aim to achieve the above-mentioned objectives:

- **Task 2.1 – Governance, coordination and quality assurance (M1-M42)**: this task encompasses all actions necessary for a seamless project implementation, including organizing and reporting all project activities as well as financial management.
- **Task 2.2 – Communication, reporting and monitoring (M1-M42)**: this task aims at establishing and performing a fluent communication within the BIMERR consortium and with the Commission as well as performing and facilitating a high quality internal and external monitoring of the project.
- **Task 2.3 – Data Management (M1-M42)**: this task's objective is the creation of a data management plan to support the potential for future sharing and reuse of the data generated within the BIMERR project.

2.2.2 Description of WP work during the Reporting Period

2.2.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

During the reporting period, there have been no deviations from the DoA in the work performed in WP2.

2.2.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

The main outcomes of this WP during the first reporting period are documented in the following deliverables:

- D2.1 – Quality Assurance Plan
- D2.1 extension -Data management Plan
- D2.2 – Periodic Report 1
- D2.5 – Periodic and Financial Report [this document]

Additionally, significant attention was paid to the implementation of two Grant Agreement Amendment processes, as briefly presented in section 2.2.2.2.2. The remainder of this section summarizes the main content of D2.1 and briefly presents the second amendment's content.

2.2.2.2.1 Quality Assurance Plan

The work towards *D2.1 – Quality Assurance Plan,* submitted in month M3, generated and established precise and productive management and quality internal procedures, implemented by the project. A continuous control on the established procedures, was acted by the Project Coordinator.

Such procedures include quality assurance and risk management, internal and external communication and reporting (including financial reporting), presentation practices (e.g. document templates, logo, layouts); preparation and submissions of deliverables, milestones approval, meetings organization and management, as detailed below.

2.2.2.2.1.1 Project General Assembly

BIMERR established a Project General Assembly (GA), which is the executive authority for the overall management and execution of the project, for the resolution of any major problems that may arise and for the decision on how to use the common knowledge resulting from the project. The Project General Assembly has met during all of the BIMERR physical plenary meetings and twice in online meetings. For each Project General Assembly meeting, agendas were proposed by the Coordinator, integrated and approved by partner's representatives. After each General Assembly meeting minutes were shared with the whole consortium on Confluence.

2.2.2.2.1.2 Document management procedure

The process for preparation, approval and submission of deliverables is as follow:

- **Deliverable Preparation** – inputs from involved partners are used by the deliverable leader to prepare its table of contents. The deliverable leader then assigns editing responsibilities to different partners, who, in turns, commit to provide their inputs within an agreed deadline. Upon reception of contributions from partners, the deliverable leader merges and harmonizes all inputs into a first consolidated version of the deliverable to be shared among contributors. Feedback from contributors is considered by deliverable leaders to finalize the first draft version "ready for internal review".
- **Internal review** – At the beginning of the project, a Confluence page was created by the Coordinator to assign two internal reviewers for each and every deliverable. Internal reviewers were selected according to the following criteria: they should have not contributed to the deliverable and they should have knowledge of the content. The assigned internal reviewers proof-read the deliverable "ready for internal review"'; their comments are documented and copied to the authors. The authors must respond by accepting or rejecting changes. Internal reviews can be iterated, if needed.
- **Deliverable submission** – The Project Manager formally submits the deliverable to the Commission following the steps listed below:
    - Final editorial checks;
    - Conversion of the document to PDF format; and
    - Upload the final version of the deliverable to the Participant Portal.

Moreover, the Project Coordinator informs all partners about the submission, and ensures that the Deliverable is uploaded to the appropriate location on the BIMERR repository (BSCW).

2.2.2.2.1.3 Risk management

The project has defined clear procedures for the management of all risks and issues that are identified at the beginning of the project or arise over its course.

The Project Manager manages and maintains the risk management log. All project participants, and in particular WP leaders, are responsible for raising any material or perceived risk as part of the normal reporting. All risks and issues must be registered in the joint Confluence wiki page. The status and mitigation of each risk element is monitored and reviewed regularly and reported at each GA meeting. FIT, as the project coordinator, manages and maintains the risk management log. At the end of the first reporting period, each WP leader indicates whether the risks occurred, the mitigation actions have been

adopted and which is the result. These information and comments are part of the formal periodic report (PART A on the Participant Portal).

D2.1 also provides the overall project management and coordination procedures that must be continuously followed by the Project Manager, Technical Manager, Scientific Manager, Dissemination & Exploitation Manager, WP Leaders and Task Leaders.

2.2.2.2.1.4 Coordination and organization

The Project Coordinator, Erion Elmasllari until the end of Q4 and Otilia Werner-Kytölä from Q5 on, is in charge of the general management of BIMERR. The coordinator is the only point of contact with the European Commission and always remains available to enquire the Project Officer for any reason on behalf of the partners.

The Project Coordinator's Organization (FIT) is also responsible for the administrative and financial management and provides support to the project partners when needed.

During the first reporting period, the administrative and financial manager supported partners both during the amendment process and the Periodic Report (Financial Part).

Interactions among partners to carry on project activities require a certain amount of communication skills and are supported by a number of practices and tools. During the first reporting period, conference calls to carry out the work in each WP have been used as required and organized by the WP leaders while status plenary teleconference meetings, involving all BIMERR partners, have been held twice a month.

The Project Coordinator has organized, in collaboration with hosting partners, 4 plenary physical meetings, including the kick-off meeting in Sankt Augustin (January 2019), where the status of all WPs had been reviewed and the plan for the next months has been agreed on. Until now, one online plenary meeting has been held during the COVID-19 time.

Additionally to physical and online meetings, communication usually takes place via email, using dedicated private mailing lists (bimerr-general, open to all project participants and bimerr-wp<*x*> (with "*x*" ranging from 2 to 10) for each work package), all managed by FIT.

2.2.2.2.1.5 Project reporting

As a means of providing a regular update on progress to all partners and to the coordinator, routine reporting takes place as follows: each partner produces a quarterly report (QMR – Quarterly Management Report) at the end of each three months on the work done in each work package and on the efforts consumed. This report is uploaded to the project repository (BSCW). The report adopts a pre-defined template that covers:

- A brief description of the work done for each WP and tasks during the period
- Deliverables and Milestones status
- Particular focus on deviations/problems encountered
- Person months consumed
- Partner's dissemination activities
- Partner's collaboration activities

2.2.2.2.1.6 Bi-weekly stand-up meeting

As a reporting activity, weekly stand up meetings are organized and managed by the coordinator (every second Monday at 11:30am CET through GoToMeeting). All partners are invited to participate and to update all the participants with activities done in the last seven days, activities foreseen in the next seven days and blocking issues. This information is shared on the project wiki page "Confluence". Partners that are not able to attend the weekly telco update the wiki off-line, so that the other participants are informed about activities performed and planned.

2.2.2.2.1.7 BIMERR Exploitable Assets

During the first reporting period, technical and exploitable assets were identified and described. They are listed below:

- **BIMERR Interoperability Framework** - The main scope of the BIMERR Interoperability Framework (BIF) is to ensure seamless and secure data exchange among the individual BIMERR tools and applications, in order to supply them with all the up-to-date building information they need for their operation and for which they are authorized. BIF utilizes mechanisms that enable semantic and syntactic interoperability, while enforcing access control policies to prevent any illegitimate building data exchange.

- **BIMERR Renovation Decision Support System (RenoDSS)** - RenoDSS provides an accurate estimation of the energy, cost, and environmental impact trade-offs of alternative renovation scenarios. The estimation of post-renovation energy consumption is based on energy data models, structural and geometrical properties of the building, materials, HVAC systems, residents' usage profile, as well as weather data. RenoDSS also takes the environmental impact of the renovation and the interaction with surrounding buildings into account.
- **Process & Worksflow Modelling and Automation toolkit (PWMA)** - PWMA provides a set of tools to design, verify, simulate, execute, monitor and analyze the reconstruction process. It orchestrates the tasks of the reconstruction process and provides UI for all the key stakeholders of the process to cover all phases of the reconstruction.
- **Scan-to-BIM** - The Scan-to-BIM Tool is a software solution for the (semi-)automated generation of as-is Building Information Models of existing buildings from reality capture data (mainly 3D point clouds and pictures). The tool deploys innovate data processing techniques, including machine learning, to deliver IFC models that can be meaningfully used for assessing building energy performance assessment and planning refurbishment.
- **Augmented Reality enabled In-situ Building Feature Annotation (ARIBFA)** - The ARIBFA tool will be responsible for presenting BIM 3D visualisations and spatially annotated information on site during the renovation process to architects, contractors and building managers through an Augmented Reality (AR) interface.
- **Profiling Resident Usage of Building System (PRUBS)** - PRUBS leverages the outcomes of Annex 66, adopting obXML as its output data model, and applies Machine Learning algorithms on IoT live data streams acquired by a sensor network that is designed and installed in the pilot sites to generate occupant behaviour profiles that mimic the inhabitants' actions. These profiles are subsequently used to identify the building system (e.g. heating/cooling) utilization boundaries that lie within the usage patterns and comfort zone of the residents.
- **Building Information Collection Application (BICA)** - The Building Information Collection Application (BICA) consists of a smartphone application intended for building residents, enabling them to provide complementary information (such as notes and photos) to the already recorded building information in the BIM, thus accelerating the overall collection of data required for the initial renovation scenario modelling process. Through BICA's UI, building residents' can provide their input spontaneously on their home indoor/outdoor areas, or at the request of the building surveyors/engineers, in order to enrich the pre-designed as-is BIM model with energy related equipment, their characteristics, building's weak points, and other related hidden components within the building (pipes, cables, etc.) that they might be aware. In addition, through BICA,

residents can also create new H&S issues, when they spot a possible H&S issue/hazard in the on-building-site (before the renovation starts).

- **Renovation material components database** - The BIMERR Material and Component Database provides technical, financial and environmental impact data for building materials and components via BIF and REST endpoint to BIMERR and external applications.
- **Ontology Manager Framework** - The Ontology Manager Framework is a collaborative environment suite to support several ontology management activities, including the documentation, evaluation, versioning and publishing of ontologies and ontology networks.
- **Building Energy Performance Estimation module (BEPE)** - BEPE transforms IFC to input data files of EnergyPlus that are used to execute BEP simulations. It enables decision support systems' users (e.g. RenoDSS) to explore various what-if scenarios, quickly run energy models (or simulations) to estimate the energy performance and fine-tune the interventions in order to explore the trade-offs.
- **BIM Management Platform** - The BIM Management Platform is an integrated cloud-based data management solution for data quality checking, versioning, and consistent updating and validation of BIM models in the form of IFC files. The platform supports a multi-tenant access paradigm supporting external requests through data access and updating APIs. The platform is based on a micro-service architecture to take advantage of the flexibility, scalability and modularity needed to support complex processing routines in an asynchronous manner, such as the geometry checking or semantic enrichment of BIM models. The platform facilitates the use and lifecycle data management of openBIM models.
- **Secure Provisioning Tool (part of BICA)** - The Building Information Secure Provisioning tool offers an access control mechanism of the data resources of the BIMERR Platform. It implements Attribute Based Access Control method where subject requests to perform operations on objects are granted or denied based on assigned attributes of the subject, assigned attributes of the object, environment conditions, and a set of policies that are specified in terms of those attributes and conditions. The component makes use of the XACML OASIS standard.

The assets identified will be further examined in the context of Task 10.4 - *Exploitation strategy and preliminary business innovation planning*.

2.2.2.2.2 Amendment process management

During the first reporting period, two amendments to the Grant Agreement were implemented. The first amendment implemented a partner change, the same team from HWU who worked for the project during Q1 has changed to UEDIN, leading to a review of the budget and fundable PMs from 39 to 43 PMs for the remaining of the project. The second amendment was created to contain all measures that handle the termination of two partners, EXE (termination date: January 22nd, 2020) and GU (termination date: January 23rd, 2020), and to handle the inclusion of one new partner, UCL. A summary of the measures that have been considered are the following:

- Redistribution of work, efforts and budget from GU to project partners;
- Reallocation of budget to purchase 5 pairs of Hololens2 to replace the GU's glasses;
- Reallocation of budget to purchase equipment needed for test sites;
- Redistribution of work, efforts and budget from EXE to XYLEM and to the new consortium partner UCL;
- Change in the submission date of deliverables D5.1 and D7.1; and
- NT transferred 2PMs from WP6 (T6.4, T6.5) to WP4 (T4.2).

In more detail, for the GU termination:

- The consortium acknowledges GU's efforts to be 3.0 PMs in total. Durable equipment and consumables were not delivered to the project, the consortium does not accept other costs claimed by GU;
- Change in deadline of deliverables D5.1 from M20 to M23, D7.1 from M13 to M20;
- WP5 leadership from GU to CERTH;
- WP5: T5.5 became void after GU termination. The project implementation is no longer based on GU's glasses, but on Hololens2 (off-the-shelf hardware), T5.1, T5.2 and T5.3, T5.4, T5.6: redistribution among partners who will execute GU's work: UEDIN, CERTH, FIT;
- WP6: CERTH takes over GU's work in T6.5;
- WP8: UEDIN, CERTH, HYPERTECH and FIT to execute GU's work;
- WP9: UEDIN, BX, CERTH, and HYPERTECH to execute GU's work;
- WP10: GU's dissemination work and budget redistributed among UEDIN, CERTH, HYPERTECH, and XYLEM

As for the EXE's termination:

- The consortium acknowledges EXE's efforts to be 9.16 PMs in total;
- WP5, T5.1: work redistributed to the new partner UCL;
- WP7, T7.1: work redistributed to XYLEM, including the task's leadership;
- WP8, T8.1: work redistributed to XYLEM, including the task's leadership;
- Apart from the leadership of task T5.1, UCL also contributes to WP8, 9, and 10.

2.2.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Table 9 provides details about the overall work by partners involved in WP2. The table inputs are collected by the WP2 leader (FIT) incorporating information from the relevant partner's QMRs.

Table 9 WP2 work done by partners during the 1st Reporting Period

Task	Partner	Activities performed in this period
T2.1	FIT	• Organized kick-off meeting • Set up quality management and reporting processes • Organized project communication and management structure • Set up reporting and collaboration infrastructure: Confluence, BSCW • Organized bi-weekly stand-up meetings for early identification of problems • Addressed issues and coordinated between partners • Defined deliverable reviewers and made an appropriate calendar for submission of deliverable on time using the defined deliverable review process • Organized the agenda for all plenary meetings • Organized the changeover and agreement changes for the HWU/UEDIN partner change • Project management and monitoring • Monitor and update quality, equality, milestones, risks as necessary
	All	• Attended and contributed to kick-off Meeting, three physical (Thessaloniki, Kosice, Athens) and one online plenary Meetings, as well as one online review meeting • Participated, contributed, and reported progress at bi-weekly stand-up meetings • Contributed to governance decisions (in particular, for planning post GU and EXE) • Contributed to D2.2 Periodic Report 1 • Contributed to 1st and 2nd project Amendments • Conducted internal reviews of several deliverables • Contributed to QMRs • Worked on D2.1 and D2.5
T2.2	FIT	• Administrative and Financial Management

		• Work on D2.1, D2.5 • Coordination and validation of QMRs • Bi-weekly progress meetings • Plenary physical meetings organization • Tracking of project activities and actions items • Monitor the progress and management of validation process for Milestones • Deliverables submission on the H2020 Research Participant Portal
T2.3	FIT	• Set up collaborative infrastructure for easily updateable data management plans, and, together with other partners, work on Data Management Plan

2.2.2.4 WP DELIVERABLES

Table 10 reports the status of deliverables foreseen for the WP during the 1st Reporting Period. For each deliverable, title, lead beneficiary, due date and submission date are reported.

Table 10 WP2 deliverables status related to the 1st Reporting Period

Deliverable	Lead	Due	Status
D2.1 – Quality Assurance Plan	FIT	M03	Submitted M03, revision M07
D2.1 extension – Data Management Plan	FIT	M03	Submitted M03, revision M07
D2.2 – Periodic Report 1	FIT	M09	Submitted M09
D2.5 – Periodic and Financial Report	FIT	M18	Submitted M20

2.2.2.5 WP MILESTONES

Table 11 reports the status of Milestones foreseen (if any) for the work package during the 1st Reporting Period. For each milestone, title, lead beneficiary, due date and status (achieved/not achieved) are reported.

Table 11 WP2 milestones status related to the 1st Reporting Period

Milestone	Lead	Due	Status
No milestones in RP1	-	-	-

2.2.3 WP Plans for the next Reporting Period

Table 12 summarizes the plans for the next period for each task.

Table 12 WP2 plans for next reporting period

Task	Partner	Planned Activities Description
T2.1	FIT, All	• Attend and report at bi-weekly virtual meetings • Attend and contribute to next physical meetings • Contribute to next periodic report • Contribute to QMRs • Monitor resources and manage them sustainably
T2.2	FIT	• Continue during the 2nd Reporting Period the coordination and organization of the main activities of the project: o Administrative and Financial Management o Periodic Report 2 o Coordination and validation of QMRs o Monthly and weekly progress teleconferences o Plenary physical meetings organization o Tracking of project activities and actions items o Monitor the progress and management of validation process on 2nd RP Milestones o Deliverables submission on the H2020 Research Participant Portal
T2.3	FIT	• Update the Data Management Plan, whenever needed • Identify data to be shared: ontologies, data sets, standards, metadata • Archiving and preservation of shared data

2.2.4 COVID-19 Impact

Some re-planning and flexibility were needed due to the pandemics. In-person consortium meetings were replaced by online meetings, while M18's review was held online and needed to be organized accordingly, e.g. we had three full-day rehearsal sessions which certainly wouldn't be needed in this extent if they were to be held face-to-face.

In general, there were partners who had to reduce their working hours to be able to take care of their children at home, since the nurseries were closed. This led to short delays on deliverables' submission (i.e. 1 to 3 weeks' delay).

For the next period, we do expect improvement on the situation, since the nurseries and schools are being opened. The project coordinator is following up tightly on submission of deliverables to avoid delays, but in a few cases, there will be a small delay of 1 to 3 weeks. Also, the project coordinator is following up tightly on the dependencies of the work to re-plan in case of delays so that the impact is minimized.

2.3 WP3 - Stakeholders Requirements, Evaluation Planning and Architecture

2.3.1 Summary of the WP objectives

The main objectives of WP3 are to:

1. understand the underlying landscape for the project activities in terms of requirements of the relevant stakeholders, available information models & standards as well as regulatory/legal frameworks that represent boundary constraints or policy modification objectives – for BIMERR activities;
2. develop a holistic methodology that describes how the BIMERR outputs will be evaluated, including KPIs and their calculations methods; and
3. define the BIMERR ICT System Architecture that will set the foundation for the design & development of all components/tools.

WP3 consists of 5 tasks which aim to achieve the above-mentioned objectives:

- **Task 3.1 – Elicitation of Stakeholder Requirements (M1-M6)**: this task aims to collect and analyse the requirements from all stakeholders that represent different steps in the renovation process but also various roles (e.g. AEC representatives, workers, project managers, residents, etc.).
- **T3.2 - Survey of Existing Building/District Data Models & Ontologies & Associated Standardization Efforts (M2-M8)**: The purpose of this task is to perform a thorough survey of the existing data models and ontologies that are already available in literature, standards as well as proprietary data models of prominent ICT tools.
- **T3.3 Development of Evaluation Methodology for the Impact of BIMERR Tools on Real Renovation Works (M2-M10)**: This task aims to review, develop and propose a methodology for the evaluation and impact assessment of the BIMERR tools.

- **T3.4 Analysis of Regulations & Markets for BIM-based Renovation-support Tools (M2-M7)**: This task is responsible for analysing the regulatory and market conditions within which the BIMERR tools will be called upon to make an impact.
- **T3.5 BIMERR System Architecture Design & Elaboration (M4-M20)**: Based on the stakeholder requirements as well as information about the available data models and market conditions, this task will deliver the overall architecture of the BIMERR system and the specifications of the key components and their functionalities.

2.3.2 Description of WP work during the Reporting Period

2.3.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

Table 13 reports relevant deviations with respect to the original WP plan as foreseen in the DoA.

Table 13 WP3's deviations description

Problem Description	Corrective actions undertaken by partners
Early in the project, it was noticed that T3.1 activities should span a larger time period in order to have enough time for collecting and processing feedback to produce the user requirements.	During the Kick-Off meeting it was decided that the D3.1 deliverable will be submitted as in M6 and it will be updated in a 2nd version with requirements produced from more stakeholders' feedback and building occupants. An update of D3.1 was provided in M18 after organising 3 additional focus workshops (2 in Spain and 1 in Poland) as well as collecting responses from 106 online questionnaires.
EXE's and GU's termination delayed D3.5.	Due to their termination, their work had to be shared among the relevant partners of the task. D3.5 submission date was postponed to M15.

2.3.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

The main outcomes of this WP during the first reporting period are documented in the following deliverables:

- D3.1 – Stakeholder requirements for the BIMERR system
- D3.2 - Survey of data models, ontologies and standards in the wider Energy Efficient Buildings domain
- D3.3 - BIMERR evaluation methodology

- D3.4 - Analysis of renovation tools market and prevailing regulatory frameworks
- D3.5 BIMERR system architecture 1st version

The remainder of this section summarizes the main content in terms of output of these deliverables.

Task 3.1 – Elicitation of Stakeholder Requirements: D3.1 presents the analysis for the end-user requirements in order to create the necessary inputs for defining the different components of the BIMERR platform and therefore setting the skeleton for the BIMERR framework. It provides a thorough description of five business scenarios that were subsequently expanded to sixteen appropriate use cases that will lead the development of the respective components that consist of the BIMERR framework. Based on the described renovation process along with the involved user groups and the subsequent grouping in the context of BIMERR, the views and requirements of each of the seven different BIMERR main user groups was collected at multiple iterations with a) four focus workshops in the pilot countries (Spain, Poland), and b) online questionnaires (in English, Spanish, Polish and Greek). The analysis of the feedback led to the definition of 151 requirements separated per user group, the different types (functional, performance, design, operational, legal, process, pilot specific), as well as a priority level (high, medium, low) in order to reflect the BIMERR project primary goals.

T3.2 - Survey of Existing Building/District Data Models & Ontologies & Associated Standardization Efforts: D3.2 presents a survey on existing data models, ontologies and standardization initiatives related to the domains potentially involved in the BIMERR Interoperability Framework (BIF) as foreseen at the beginning of the project. More precisely, the domains included in the deliverable are: building (including structure and components), materials, energy consumption, usage patterns and habits, weather, reality capture and GIS. In total 31 data models, 15 ontologies and 14 standardization initiatives were described. In order to select and assign the domains, the domains were listed by partners in series of brainstorming sessions by means of teleconferences and assigned to the partners more familiar with each domain. The analysis, description and generation of the survey was done in a collaborative way among all the partners involved in the task.

T3.3 Development of Evaluation Methodology for the Impact of BIMERR Tools on Real Renovation Works: D3.3 considers the tools of the BIMERR platform and is designed based

on well-established international methodologies and protocols, reviewing the current status and relevant BIM projects, as well as reviewing relevant renovation works and expertise of the BIMERR constructor partners. The use of BIMERR tools in real renovation works in the context of the use cases proposed in D3.1 is considered along with the four major impact KPIs, namely reduction of renovation process duration, reduction of the renovation process cost, improvement of user acceptance and increase in energy efficiency. For each of them a list of complementary KPIs is provided along with the necessary input parameters and the required calculations, as well as ways were identified in order to capture this information during the piloting activities (e.g. historical data, sensor measurements, user feedback via the provided purpose made questionnaires). Overall, 31 KPIs were identified related to renovation time and cost (17 of them are also linked to BIMERR tools accuracy), 14 KPIs related to energy efficiency, 26 KPIs related to user acceptance, 8 KPIs related to occupants comfort, 10 KPIs related to sustainability and economic KPIs.

T3.4 Analysis of Regulations & Markets for BIM-based Renovation-support Tools: D3.4 involves the market research and analysis of AEC regulations in the UK and several EU countries, especially Poland and Spain where the pilots of the project will be conducted, and at a lesser extent in Greece where the pre-pilots are held. This work identifies the key directives to drive the use of BIM within renovation activities, the stakeholders involved, the market size and potential, needs and value propositions that BIM-Based Renovation support tools must fulfil. The mandates of all European countries involving the use of BIM tools are reviewed and consolidated as well as all the legal and regulatory frameworks and directives of the EU, federally and nationally. The work was consolidated through a PESTEL analysis for Poland and Spain in particular, and the findings provided the indications for potential exploitation pathways of BIMERR results in these countries. Furthermore, the regulations and directives with regards to energy efficiency/ heating and cooling renovations were reviewed and a SWOT analysis of BIMERR in the targeted markets was performed.

T3.5 BIMERR System Architecture Design & Elaboration: D3.5 drafted in this reporting period the main high-level architecture scheme of the entire system and the intermediate-level architecture schemes of the main building blocks of the system. On the highest level, the BIMERR architecture is comprised of 5 main components: 1. BIMERR Interoperability Framework (BIF); 2. BIMERR Middleware; 3. Digital Building Modelling Tools; 4. Renovation Support Tools; 5. BIMERR UIs.

For the intermediate level, starting with the use case definitions and the requirements documented in the work of D3.1, the survey of existing data models and ontologies from D3.2, the evaluation methodology from D3.3 and the analysis of regulations and markets from D3.4, each partner designed and documented their sub-component's specifications, functionalities, inputs and outputs within the overall architecture and within each main component it belongs to. This work was performed in order to define the architecture into two main views: the structural view, describing the core components of the system in the form of software modules, and the dynamic view, which presents the already defined use cases with the corresponding sequence diagrams.

The work above was complemented with an overview of the Data Exchange and Interoperability requirements, including data flow, protection and privacy requirements along with a preliminary Data Protection Impact Analysis. Finally, roadmaps detailing the development milestones of each sub-component were defined and reported in order to be able to monitor the progress of each component and how it impacts the overall architecture.

2.3.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Table 14 provides details about the overall work by partners involved in WP3. The table inputs are collected by the WP3 Leader (UOP) incorporating information from the relevant partner's QMRs. In order to avoid repetition, it has to be mentioned here that all partners have participated in the relevant task teleconferences.

Table 14 WP3's work done by partners during the 1st Reporting Period

Task	Partner	Activities performed in this period
T3.1	UOP	• BIMERR Business Scenarios and Use Cases definition (available on the project official repository - *BIMERR Business Scenarios and Use Cases - v1.1.pdf*) • Renovation Process definition (available on the project official repository - *Phases.and.Steps-v2.pdf*) • Stakeholders and Questionnaires: the 1st version of the questionnaires focused on supporting the requirements workshops (available on the project official repository - *Questions for Workshop- v1.1.pdf*); the 2nd version of the questionnaires focused on the online survey conducted in the framework of Living Labs (available on the project official repository - *Questions for online survey - v1.pdf*) • D3.1 preparation, review, submission in M06 (D3.1-Stakeholder

		requirements for the BIMERR system v1.0.docx) • Processing the reports from the four Requirements Workshops organized by the pilot partners BX and FER • Second compilation and subsequent update of BIMERR user requirements (Requirements - interim - v2019.12.08) • Processing the online questionnaires until end of June 2020, preparation of the update of D3.1 and submission on M18 (D3.1-Stakeholder requirements for the BIMERR system - final.docx)
	FIT	• Provided feedback for the methodology in D3.1
	SUITE5	• Contribution to the definition of business scenarios and use cases with focus on those involving the BIF and BICA components • Contribution to the drafting and finalization of the questionnaires towards the end-users of the project with focus on BIF and BICA • Elicitation of end-user requirements based on questionnaire responses and living lab workshops feedback • Preparation, update and finalization of the overarching story of the BIMERR project for creating a common understanding of the project among partners • Contribution to the preparation and finalization of D3.1 - Stakeholder requirements for the BIMERR system
	UBITECH	• Contribution to non-functional and technical requirements definition
	HYPERTECH	• Contribution to the use cases relevant to the Building Energy Performance and the Profiling Residents Usage of Building Systems (PRUBS) components evaluation/validation • Feedback provision on the methodological framework of D3.1 • Provided extensive feedback for all use cases
	MERIT	• Established connection with T10.2 - Living Lab Activities to organize T3.1 workshops • Reviewed business scenarios and use cases • Provided the platform for the online questionnaires to collect the user requirements • Gathered all the responses from the online questionnaires and provided the data along with demographics of the participants
	XYLEM	• Contribution to and review of the business scenarios, the stakeholder requirements and the use case questionnaires • Contributed to the overarching story/vision
	GU	• Participation in the business scenarios definition and use cases analysis
	CONKAT	• Participation in the business scenarios and use cases definition from the scope of a construction company • Contributed to the user questionnaires
	BOC	• Contribution to the business scenarios and the use case questionnaires • Project, meetings and WP kick-off contributions
	BX	• Contribution to the definition and description of Use Case, Business Scenarios and renovation processes.

		• Preparation and review of material/documents for workshops and online questionnaires such as. general BIMERR presentation, questionnaires [developed by UOP] for each stakeholder, agreements for use of individuals' images and agreement for processing of personal data), all the material was translated into polish • Organization of two workshops (3 hours each) in Poland (Warsaw) each with 7 participants, and an additional meeting with BIM experts. • Evaluation of the workshop results and after their translation to English provided input to D3.1.
	EXE	• Provided feedback for the methodology for D3.1
	UEDIN	• Contribution to the description of Business Scenarios and developed the Use Cases for the Scan-to-BIM process and tool(s)
	NT	• Worked on the business scenarios and the analysis of different use cases
	FER	• Contributed to the definition and description of Use Case, Business Scenarios and renovation processes. • Reviewed the requirements questionnaires and translated them into Spanish (both for workshop questionnaires and for the online questionnaires). • Organized two workshops in Madrid (5 participants, 3 hours workshop) and Valencia (7 participants, 3 hours workshop) • Evaluated the workshop results and after their translation to English provided input to D3.1. • Devised a strategy to increase online questionnaire responses (e.g. posted information about the online questionnaire on the social media channels of the neighbourhood of the Spanish pilot building).
T3.2	UPM	• Plan, design methodology and coordinate the generation of D3.2 • D3.2 contributions about ontologies and data standardization initiatives for D3.2 and general sections • Final integration and delivery of D3.2 in M08
	FIT	• Contributed to D3.2 drafting
	CERTH	• Literature review of existing data models, ontologies and standards in the Materials and Geographic Markup domains • Contribution to D3.2 drafting and editing
	UBITECH	• Contribution to SOTA research and Weather and Geolocation ontologies
	SUITE5	• Completion of the detailed survey of data models, ontologies and standards in the domains of Building Structure (indoor and interior data space models), Building Components, Information Exchange in Construction Operations • Report of the survey results in D3.2 - Survey of data models, ontologies and standards in the wider Energy Efficient Buildings domain
	HYPERTECH	• Literature review of existing data models, ontologies and standards in the Building Energy Performance Modelling and the Usage Patterns and Habits Modelling domains. • Report of the literature review results in D3.2.

	MERIT	• Feedback provision on "Analysis of the usage patterns and habits domain" section and proposed a scope reconsideration to be aligned with task objective. • Contribution to D3.2 drafting and reviewing.
	XYLEM	• Contributed to D3.2, specifically the sections: gbxml, ifcowl, and relevant material data models and ontologies in the field of building materials • Edited D3.2, specifically section "Analysis of the usage patterns and habits domain"
	EXE	• Contribution to D3.2 content drafting
	UEDIN	• Conducted and reported on survey of existing standards, data models and ontologies related to surveying (reality capture data) and Building Information Modelling (BIM). • ESWC 2019: Collaborated with UPM team in the BIMERR presentation.
T3.3	UOP	• Review of methodologies followed by other EU projects, relevant to BIMERR, that are used during project's validation activities for impact assessment (available on the project official repository (*Review.of.Existing.Methodologies_v0.1.docx*)) • Production of the methodology for assessing energy savings, renovation cost and time reduction and user acceptance. • Discussions with task and then consortium partners for the proposed methodology • Preparation of deliverable D3.3, review and submission on M10.
	CONKAT	• Contribution to D3.3 with the overview of existing "methodologies for time and cost performance evaluation used in the industry". • Recognised the Earned Value Analysis (EVA) and the Critical Path Method (CPM) as the most widely used methods to evaluate the time and cost performance.
	BX	• Revision of the existing methodology regarding steps in renovation projects and their average costs and time estimation, based on experience related to renovation projects carried out by Budimex • Identified and described viable examples from real renovation/retrofitting works in Poland with data for cost and time
	UEDIN	• Conducted and reported on extended survey of the literature to identify existing evaluation methodologies for the impact of BIMERR Tools in terms of time and cost.
	FER	• Reviewed the existing methodology regarding cost and time estimation of renovation projects. • Searched for and identified viable examples from real renovation/retrofitting works in Poland and Spain with data for cost and time.
T3.4	EXE	• Overviewed industry publications, prepared questionnaires and gathered feedback from consortium partners, and also analysed government legislation • Preparation of D3.4, review and submission on M7

	CERTH	• Completion of questionnaire regarding Greek regulations and market scope • Greek market and regulatory analysis to be used in this task • Contribution to an internal review of D3.4
	MERIT	• Completed the questionnaire regarding initial market and regulatory analysis in Belgium • Internal review for D3.4
	CONKAT	• Contribution for the questionnaire regarding the market analysis • Review of the Greek construction market and regulatory conditions for BIM implementation to be used in this task.
	BX	• Elaboration of the input in EXERGY's Questionnaire about the Market Analysis.
	NT	• Screening of the BIM market in Slovakia • Contributed to D3.4
	FER	• Input to EXERGY's Questionnaire about the Market Analysis
T3.5	CERTH	• Preparation, Organization and hosting of weekly teleconferences for the definition of the System Architecture • Definition of high-level architecture design methodology • Drafting of Conceptual architecture diagrams • Definition of component functionalities, specifications and inter-connectivity based on shareholder requirements • Initial drafting of sequence diagrams stemming from the use cases definitions • Leadership in Drafting of D3.5 and organization of partner contributions, editing of the document • Contribution to all sections of the deliverable including specific ones regarding the ARIBFA component • Preparation to resume activities to update the BIMERR architecture and to better integrate BIM Management Platform
	FIT	• Contributions to D3.5 for Middleware, Data flow, networking, and communication requirements
	UPM	• Participated in architecture discussions • Contributed to architecture description of semantic components • Set up of example case for showcase semantic technologies • Definition to architecture diagrams • Contributions to discussion and definition of Building semantic modelling tools & Building information collection and enrichment tools architecture • Contribution to D3.5 (Building semantic modelling tools, Building information collection and enrichment tools, ontology manager framework and knowledge graph generator)
	UBITECH	• Contributions to the BIMERR Architecture with regards to the Query Builder and Building Information Secure Provisioning Tool • Contribution to D3.5 (providing component specification for Query Builder)
	SUITE5	• Contribution to the drafting of conceptual architecture diagrams

		• Coordination with other WP4 partners regarding the integration of the respective components of the BIMERR BIF into the overall architecture of the project and the details of their functionality • Contributions to the BIMERR Architecture for the BIMERR Interoperability Framework (in particular, for the Building Semantic Modelling Tools and the Building Information Collection and Enrichment Tools) and the BICA application (description, component architecture, roadmaps). • Alignment of all BIF contributions under the BIMERR architecture. • Elaboration on the Use Case UC-7 related to the "Stakeholders' systems exchange appropriate and "understandable" data between each other". • Internal review of draft D3.5.
	HYPERTECH	• The "Building Energy Performance Modelling" and the "PRUBS" components specifications' have been reported - a first attempt towards reporting the input/output data requirement of both components • Gateways and sensor specifications have been proposed as part of the PRUBS component specifications to ensure that the system is running according to PRUBS requirements • Contribution to D3.5 for the Building Energy Performance modelling and PRUBS tools (roadmaps, sequence diagrams, specifications, high-level architecture)
	MERIT	• Defined a high-level methodology, aligned with the EU GDPR guidelines with particular steps for DPIA conduction
	XYLEM	• Contributed to D3.5 (RenoDSS architectural component specification)
	GU	• Coordination with work in WP5 • AR glasses technical specifications
	BOC	• Coordinated the progress of this task with WP6 partners, in meetings and deliverable D3.5 contributions as well as in meetings • Correlated the PWMA Toolkit (WP6) architecture with the progress of this task via a Microservice Framework for Process-Oriented Decision Support • Contributed to the BIMERR system architecture
	UOP	• Initial work on the definition of the BIMERR architecture based on results from D3.1 • Contribution to deliverable D3.5 with high-level description of BIMERR use cases and updated list of user requirements
	EXE	• *The contribution by Exergy related to D3.5 was handled by CERTH*
	UEDIN	• Contributed for the Scan-to-BIM Tool (Description of Use Case 1 and sequence diagrams, component specification analysis)
	NT	• Contribution to D3.5 content drafting

2.3.2.4 WP DELIVERABLES

Table 15 reports the status of deliverables foreseen for this WP during the 1st Reporting Period. For each deliverable, the title, the lead beneficiary, the due date and the submission date are reported.

Table 15 WP3's deliverables status related to the 1st Reporting Period

Deliverable	Lead	Due	Status
D3.1 – Stakeholder requirements for the BIMERR system	UOP	M06	Submitted M06, update finalized M18
D3.2 - Survey of data models, ontologies and standards in the wider Energy Efficient Buildings domain	UPM	M08	Submitted M08
D3.3 - BIMERR evaluation methodology	UOP	M10	Submitted M10
D3.4 - Analysis of renovation tools market and prevailing regulatory frameworks	EXE	M07	Submitted M07
D3.5 BIMERR system architecture 1st version	CERTH	M12	Submitted M15

2.3.2.5 WP MILESTONES

Table 16 reports the status of milestones foreseen (if any) for the work package during the 1st Reporting Period. For each milestone, the title, the lead beneficiary, the due date and the status (achieved/not achieved) are reported.

Table 16 WP3's milestones status related to the 1st Reporting Period

Milestone	Lead	Due	Status
MS1 - End-user requirements elicitation & documentation	UOP	M06	Reached M6
MS2 - BIMERR system architecture definition	UOP	M12	Reached M15
MS13 - Use Cases and Scenarios ready	UOP	M12	Reached M10

2.3.3 WP Plans for the next Reporting Period

Table 17 summarizes the plans for the next period for each task.

Table 17 WP3 plans for next reporting period

Task	Planned Activities Description
T3.1	This task ended in M06
T3.2	This task ended in M08
T3.3	This task ended in M10
T3.4	This task ended in M07
T3.5	All partners, led by CERTH, will update the system architecture considering the findings from the development activities and provide the final version of the BIMERR System Architecture (D3.6) in M20.

2.3.4 COVID-19 Impact

The arrangements of physical meetings with occupants for collecting user requirements were impacted by the pandemics. This was counterbalanced with online surveys. Most tasks in WP3 have finished in the first reporting period (T3.5 finishes in M20), so there are no corrective actions required.

2.4 WP4 - BIMERR INTEROPERABILITY FRAMEWORK

2.4.1 Summary of the WP objectives

In accordance with the BIMERR DoA, the objectives of WP4 are:

1. To identify, understand and analyse existing data models and ontologies related to the domain of building renovation for energy-efficiency and more broadly to the Architecture, Engineering and Construction (AEC) industry.
2. To design and develop the BIMERR ontologies and data models that will provide the semantic foundation for the BIF and the overall project applications & activities.
3. To create and deliver the BIMERR Interoperability Framework (BIF) that addresses semantic interoperability challenges for seamless building data exchange throughout the renovation process of existing buildings, from project conception to delivery.

WP4 consists of the following six tasks which aim to achieve the above-mentioned objectives:

- **Task T4.1 - Analysis of EEB-related Ontologies and their Semantic Links (M5-M10)**, with the main purpose of further analysing the ontologies, data models and standards (that have been initially identified in T3.2) in order to evaluate the extent to which they already cover the data exchange needs between the BIMERR applications.

- **Task T4.2 - Data Modelling & New Ontology Definition (M8-M30)** that iteratively designs and delivers the BIMERR ontologies and data models across different (building-related) domains, which are put into use in the Building Semantic Modelling component (in T4.3) for the semantic mapping of the data exchanged in BIMERR through the BIF.
- **Task T4.3 - Building Semantic Modelling Tools Creation (M8-M30)**, which is responsible for the design and development of the Building Semantic Modelling Component (BSM) that ensures: (a) the semantic consistency and reconciliation of the building data exchanged through the BIF with the BIMERR ontologies and data models (defined in T4.2), and (b) the alignment and lifecycle management of the BIMERR ontologies and data models.
- **Task T4.4 - Building Information Collection and Enrichment Tools Creation (M10-M30)**, aiming at specifying and delivering the Building Information Collection and Enrichment Component (BICE) that effectively ingests (through different modalities), handles and stores building-related data from the BIMERR applications and any external, third-party system (in collaboration with the BSM).
- **Task T4.5 - Building Information Secure Provisioning Tool Creation (M11-M30)**, that is responsible for the development and deployment of the Building Information Secure Provisioning Component (BISP) that manages secure data access control based on user-defined policies and strategies that are dynamically enforced.
- **Task T4.6 Building Information Query Builder Creation (M11-M30)**, with the purpose of designing and developing the Building Information Query Builder Component (BIQB) that allows for faceted search over the building-related data available in BIF and secure acquisition of the exact data needed (in collaboration with BISP and BICE). T4.6 is also responsible for the BIF integration activities.

2.4.2 Description of WP work during the Reporting Period

2.4.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

During the reporting period, there have been no deviations from the DoA in the work performed in WP4. It needs to be noted though that, as anticipated, the technology stack that has been deployed for the BIF has deprecated certain architecture references in the DoA. For example, the T4.4 description in the DoA underlined the need for wrappers for the functional coupling of the various tools, yet such wrappers are not needed anymore as all the

necessary mapping and transformation processes to be applied over the data towards their semantic reconciliation and interoperability are already performed in the BIF.

2.4.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

During the first reporting period, all the WP4 tasks have been active, have concluded their first iteration and have documented their respective results as planned in the DoA. In particular:

Task T4.1 - Analysis of EEB-related Ontologies and their Semantic Links, led by UPM. In the context of the T4.1 activities, the scope of the BIMERR ontology, the preliminary data requirements (envisioned for the BIMERR ontology/data model and classified in accordance with the domains of T3.2, namely: Building, Material, Energy Consumption, Usage Pattern and Habits, Weather, Reality Capture, GIS and Project Management) and their coverage by existing data schemas, as well as the semantic links identified among models, are elaborated on the basis of the adopted methodology in this task. In essence, T4.1 consolidates a preliminary data requirement analysis defining the general scope of the BIMERR ontologies and data models and their coverage by existing data schemas while identifying an initial set of ontologies and data models on which BIMERR may build upon in the next phases of the project. Overall, 48 preliminary requirements have been extracted from 16 use cases (as defined in T3.1) and their coverage in 13 ontologies (10 ontologies and 3 equivalent to respective data models) and 20 data models by means of mapping each requirement to the ontologies and data models is analyzed. These requirements along with their coverage analysis, set the basis for the detailed data requirements generation activities in T4.2 where refinements, extensions and prioritization are iteratively expected. The outcomes of T4.1 have been reported in D4.1 "Report on Semantic Alignment & Linking of EEB-related Ontologies" that was released on M10.

Task T4.2 - Data Modelling & New Ontology Definition, led by UPM: Building on and adapting state-of-the art methodologies, the methodology followed in T4.2 for the design, implementation and publication of the BIMERR ontology and data model has been consolidated. T4.2 has also focused on the scope of the ontologies and data models in BIMERR highlighting how both conceptualizations are related, as well as on their alignment and unambiguous translation through a set of assumptions and rules to follow. Since the T4.2 activities practically complement and extend the analysis undertaken in T4.1, every subdomain of the BIMERR ontology is described in detail, indicating its requirements and the current model description. More specifically, four domains are covered by the BIMERR ontology network namely: Occupancy Profile, Sensor Data, Key Performance Indicators (KPIs)

and Weather as reported in D4.2 "BIMERR Ontology & Data Model 1" that was released on M15. Since then, the latest, preliminary ontologies (e.g. Building, Material Properties, Renovation Measures) have become available online in different formats in the BIMERR ontology network portal. It is anticipated that new concepts and relations will be continuously discovered as new needs appear from the different BIMERR applications that are currently under development in WP5-WP7. Therefore, such ontologies shall naturally evolve in the upcoming months in parallel with the definition and implementation of the pending ontologies.

Task T4.3 - Building Semantic Modelling Tools Creation, led by Suite5: In alignment with the BIMERR architecture defined in T3.5, the BIMERR Building Semantic Modelling Component (BSM) relies on the complementary use of ontologies and data models taking the best of breed of both data modelling paradigms in its Ontology Manager Framework (OMF), its Model Mapper (MM) and its Model Lifecycle Manager (MLM). The three subcomponents that constitute the BIMERR Semantic Modelling Component build on over 15 state-of-the art technologies to deliver the intended functionalities for: (a) the users, i.e. BIMERR applications owners/developers that act as building data providers to the BIF, and (b) the data model and ontology managers that are responsible for managing the creation, evolution and alignment between the BIMERR data models and ontologies. The initial release of the BSM component builds on the T4.2 outcomes and is documented in detail in D4.4 "BIMERR Building Semantic Modelling tool 1" that was released on M17. In particular, the documentation provided for the BSM (along with its subcomponents) is oriented towards the functionalities it broadly delivers, the technology stacks it builds upon, the APIs it exposes, the installation instructions and usage walkthroughs it offers to its users. It needs to be noted that as it is only at the initial release level, BSM does not fully implement all the envisaged functionalities, depends on certain assumptions, and imposes a set of restrictions while it shall be constantly updated with new functionalities and fixes, whenever necessary.

Task T4.4 - Building Information Collection and Enrichment Tools Creation, led by Suite5: In the context of the T4.4 activities, the BIMERR Building Information Collection & Enrichment Component (BICE) has been designed and developed to play an instrumental role in BIF from the perspective of the building-related data providers. BICE is practically responsible for collecting building-related data in multiple modalities (through APIs or as files), processing them according to the provisions of the relevant BIMERR data models (that are aligned with the BIMERR ontologies), and finally storing and indexing the transformed data along with their accompanying information so as to be eventually available to all authorized BIMERR applications. The BIMERR Information Collection & Enrichment Component has delivered five subcomponents, namely the Data Ingester & Fetcher, the Data Handler, the Data Storage & Indexing, the Master Controller and the Knowledge Graph

Generator. Such subcomponents build on over 20 state-of-the art technologies to deliver the planned functionalities for the intended users, i.e. BIMERR applications owners/developers that act as building data providers to the BIF. The initial release of BICE is documented in D4.6 "BIMERR Information Collection & Enrichment Tool 1" that was released on M17 and provides a comprehensive overview of the actual software which has been developed (for the first iteration) and delivered in accordance with the BIMERR requirements and architecture. In more detail, the functionalities that BICE broadly delivers, the technology stacks it builds upon, the APIs it exposes, the installation instructions and end-to-end usage walkthroughs it offers to its users are explained. As BICE is in its initial release at the moment, it has not yet fully implemented all the envisaged functionalities, but depends on certain assumptions, imposes a set of restrictions, and updates and fixes are constantly performed during the testing period.

Task T4.5 - Building Information Secure Provisioning Tool Creation, led by UBITECH: The Building Information Secure Provisioning Component (BISP) delivered through the T4.5 activities brings to BIF, enhanced security and access control functionalities over the building data that are to be exchanged among the different BIMERR renovation applications. An Attribute-Based Access Control mechanism (ABAC) has been designed in accordance with the BIMERR needs and developed in order to enforce access policies that have been defined by the BIMERR applications that act as data providers, at data query and data provisioning time. In order to effectively handle the access policies definition, management and enforcement in a loose coupled manner, BISP consists of four subcomponents, namely the Access Policy Manager, the Policy Enforcement Business Logic, the Access Request transformation Handler and the Attributes Handler. The initial release of the BISP component in T4.5 has been documented in D4.8 "Integrated BIMERR Interoperability Framework 1" that is released on M18. D4.8 practically reports the functionalities that are supported by BISP, rationalizes the technology stack selection, outlines the APIs that have been exposed, and provides a usage walkthrough for the creation and management of access policies. As it happens for all BIF components, BISP relies on certain assumptions and imposes a set of restrictions at the moment, yet the development activities of BISP are ongoing to provide additional functionalities or fixes, whenever necessary.

Task T4.6 Building Information Query Builder Creation, led by UBITECH: The focus of the T4.6 activities is on: (a) the design and development of the Building Information Query Builder (BIQB) component, and (b) the integration activities among the BIF components developed in T4.3 (BSM), T4.4 (BICE), T4.5 (BISP) and T4.6 (BIQB) in order to release the initial BIF platform. As explained in T3.5, BIQB is responsible for facilitating the search over the building data that are available in the BIF and granting access to the exact data an authorized application needs (considering the applicable access policies in BISP). To this end, BIQB offers

different options to the application developers acting as BIF data consumers to find the data their application needs and acquire them via the BIF API (that BIQB effectively exposes and whose access manages through appropriate security mechanisms). BIQB allows for saving a query, configuring its results and acquiring them directly from the BIMMER applications while at the same time, in the background BISP enforces the necessary access policies and BICE appropriately prepares the requested data. The initial release of the BIQB component in T4.6 has been documented (in terms of functionalities, technologies, and usage walkthroughs) in detail in D4.8 "Integrated BIMERR Interoperability Framework 1" that is released on M18. The initial release of BIQB also relies on a number of assumptions and imposes some restrictions at the same time when the development activities of BIQB are ongoing to provide additional functionalities or fixes, whenever necessary. Finally, within the context of this task, the first version of the integrated BIF has been delivered, providing the implementation of a set of core functionalities that can be organized into three core workflows: a) the data collection workflow (basic BIMERR application workflow), b) the data search and retrieval workflow (basic BIMERR application workflow), and c) the ontology and data model preparation workflow (ontology and data model administrator workflow). Furthermore, in T4.6, the first version of the integrated BIF user interface that lines the frontend environment of the different components with the produced backend services and backbone infrastructure has been delivered.

2.4.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

The activities and work performed by the different BIMERR partners involved in WP4 are detailed in the following table.

Table 18 WP4's work done by partners during the 1st Reporting Period

Task	Partner	Activities performed in this period
T4.1	UPM	• Leadership of T4.1 activities, coordination of T4.1 telcos and delivery of D4.1 • Initial analysis of the scope and requirements of BIMERR ontology, as well as of potential ontologies to be reused • Coordination of D4.1 contribution per partner considering the T3.2 inputs • Mapping the general requirements to sensor and weather ontology/data models and bot ontology
	CERTH	• Participation at T4.1 telcos • Contribution on the data exchange requirements analysis for the Materials domain • Extraction of data exchange requirements from Use Cases 01, 02, 08, 10-12 (D3.1)
	UBITECH	• Participation at T4.1 telcos and contribution in D4.1

Task	Partner	Activities performed in this period
		• Participation in alignment and semantic linking of the ontologies and data models with the BIF • Analysis and Evaluation of applicability of ontologies identified in the Weather and GIS domains in the BIMERR scope
	SUITE5	• Organization of the WP4 technical meeting in Limassol for launching the WP4 activities and coordinating the efforts of all partners across the WP4 tasks • Participation at T4.1 telcos and contribution in D4.1 • Evaluation of the suitability of data models/ ontologies/ standards in the "Building Structure" and the "Building Components" domains, to the BIMERR scope. • Extraction of data exchange requirements from Use Case 07 (D3.1) • Review of the D4.1 draft and contribution to its finalization
	HYPERTECH	• Participation at T4.1 telcos and contribution in D4.1 • Evaluation of the suitability of data models/ ontologies/ standards in the "Building Energy Performance Modelling" and the "Usage Patterns and Habits Modelling" domains, to the BIMERR scope. • Contribution to tables analysing the existing data models/ontologies capability on capturing high level data requirements of the BEPE and PRUBS tools • Extraction of data exchange requirements from Use Cases 03, 15 (D3.1) • Review of the draft D4.1 and contribution to its finalization
	MERIT	• Participation at T4.1 telcos and contribution in D4.1 • Feedback on the "usage patterns and habits domain" data and ontological requirements. • Search for dissemination opportunities in the EEB-related Ontologies and their Semantic Links domain.
	XYLEM	• Participation at T4.1 telcos and contribution in D4.1 • Contribution to the mapping of requirements to data models • Extraction of data exchange requirements from Use Cases 13, 14, 16 (D3.1)
	CONKAT	• Participation at T4.1 telcos • Advisory role throughout T4.1 based on construction-domain expertise. • Cross-check of the alignment of the "BIMERR ontological requirements" with the "Stakeholder requirements for the BIMERR system" that have been documented in D3.1.
	BX	• Participation at T4.1 telcos
	UEDIN	• Participation at T4.1 telcos and contribution in D4.1 • Evaluation of the suitability of data models/ ontologies/ standards in the "Reality Capture" domains, to the BIMERR scope. • Contribution to ontologies and data standardization review, primarily about building modelling (IFC) • Contribution to requirements table from Use Case 01 (D3.1)
	FER	• Participation at T4.1 telcos • Review, check and comment regarding the "requirement coverage analysis"

Task	Partner	Activities performed in this period
		• Overall review of the draft D4.1
	NT	• Extraction of data exchange requirements from Use Cases 05, 09 (D3.1)
T4.2	UPM	• Leadership of T4.2 activities and delivery of D4.2 • Definition of the ontology development methodology • Coordination of the ontology development process, setting the mechanism for gathering data exchange requirements • Development, deployment and maintenance of the BIMERR ontologies portal • Draft ontology models for KPIs, renovation measures, materials and building • Refinement and evolution of all ontology models
	FIT	• Participation at T4.2 telcos
	CERTH	• Participation at T4.2 telcos and contribution in D4.2 • Contribution to the data requirements of ARIBFA
	UBITECH	• Participation at T4.2 telcos and contribution in D4.2 • Definition of the scope of the ontology and alignment with the data models in BIMERR
	SUITE5	• Participation at T4.2 telcos and contribution in D4.2 • Definition of the BIMERR data model template and alignment with the ontology through specific rules • Contribution to the method for the collection of data requirements from the BIMERR applications. • Contribution to the data modelling activities of different domains that are related to the BICA application. • Review of the D4.2 draft • Insertion of additional information required in the BIMERR data models for KPIs, renovation measures, materials and building (that were automatically extracted from the BIMERR ontologies)
	HYPERTECH	• Participation at T4.2 telcos and contribution to D4.2 • Contribution to the data sources, detailed requirements and modelling in the context of the BEP and PRUBS tools
	XYLEM	• Participation at T4.2 telcos and contribution to D4.2 • Contribution to data requirements and modelling for renovation measures, materials, components • Contribution to RenoDSS-relevant data exchange requirements (renovation measures, materials, components) • Contribution to the building material ontology and data model • D4.2 Review
	UEDIN	• Participation at T4.2 telcos and contribution in D4.2 • Contribution to the IFC-related data requirements (mainly Building Geometry, Materials information modelling, Geo-referencing) for the Scan-to-BIM Tool • Contributed to discussions on: Building Geometry, Materials information modelling, Geo-referencing
	NT	• Participation at T4.2 telcos

Task	Partner	Activities performed in this period
		• Participated on discussions on the data requirements related to PWMA
T4.3	SUITE5	• Leadership of T4.3 activities, organization of WP4 telcos and delivery of D4.4 • Experimentation with different technologies for the Building Semantic Modelling component • Detailed design and specs for BSM • Front-end and back-end implementation of the Model Mapper • Back-end implementation of the Model Lifecycle Manager
	FIT	• Participation at WP4 telcos
	UPM	• Participation at WP4 telcos and contribution in D4.4 • Development of generation and alignment methods from ontology to data model • Development of the Ontology Manager Framework • Development of the first prototype of the Data model generation from ontologies (BO2DM), along with improvements. Web service development for the BO2DM service • Automation of ontology new versions publication from git • Contribution to D4.4 • Review of D4.4
	UBITECH	• Participation at WP4 telcos and contribution in D4.4 • Contribution to the technologies selection, design and testing for BSM in alignment with the BIQB needs.
	HYPERTECH	• Participation at WP4 telcos and contribution to the ontology and data model alignment in D4.4 • Review of the draft D4.4
T4.4	SUITE5	• Leadership of T4.4 activities, coordination of telcos and delivery of D4.6 • Experimentation with different technologies for the Building Information Collection and Enrichment component • Detailed design and specs for the overall BICE • Front-end and back-end implementation of the Data Ingester & Fetcher and Data Handler • Back-end implementation of the Data Handler, Master Controller and Data Storage • Integration between BICE and BSM
	FIT	• Participation at WP4 telcos and contribution in D4.6 in respect to the integration with the BIMERR Middleware
	UPM	• Participation at WP4 telcos and contribution in D4.6 • Testing of knowledge graph generation technologies • Design, implementation, and deployment of service for epw files collection • Generation of mappings for KGG for weather domain • Contribution to D4.6
	UBITECH	• Participation at WP4 telcos and contribution in D4.6 • Contribution to the technologies' selection, design and testing for the BICE in alignment with the BISP needs.

Task	Partner	Activities performed in this period
	XYLEM	• Participation to the WP4 telcos • Review of draft D4.6
	UOP	• Participation at WP4 telcos and contribution in D4.6 • Feedback on the data ingestion methods to be supported in BICE
	UEDIN	• Participation at the WP4 telcos • Review of draft D4.6
T4.5	UBITECH	• Leadership of T4.5 activities, contribution to the WP4 telcos and delivery of D4.8 • Definition of the Access Policies template and coordination tasks for the definition of the Access Policies • Experimentation with different technologies for BISP • Detailed design and specs for BISP • Backend and frontend development of the BISP core functionalities • Participation in discussions related with the role of BISP as BIMERR's central access control component
	FIT	• Participation at WP4 telcos • Contribution to the integration of BISP and Identity Provider • Participation in discussions related the role of BISP as BIMERR's central access control component
	CERTH	• Participation at WP4 telcos • Contribution to the data security requirements and access policies of ARIBFA, PWMA Residents' app
	UPM	• Participation at WP4 telcos • Discussion on the role of access policies for KGG
	SUITE5	• Alignment and integration points between the BICE and BISP • Contribution to the access policies template and inputs for BICA • Contribution to the technology selection, design and testing of BISP • Investigation how the BISP access policy mechanism affects the overall BIF, esp. BICE
	HYPERTECH	• Participation at WP4 telcos • Contribution to the data security requirements and access policies of PRUBS
	XYLEM	• Participation at WP4 telcos • Contribution to the data security requirements and access policies of RenoDSS
T4.6	UBITECH	• Leadership of T4.6 activities, contribution to the WP4 telcos and delivery of D4.8 • Definition of the Queries template and coordination tasks for the definition of indicative Queries by the BIMERR applications • Experimentation with different technologies for BIQB • Detailed design and specs for BIQB • Backend and frontend development of the BIQB core functionalities • Integration activities for the overall BIF

Task	Partner	Activities performed in this period
	FIT	• Participation at WP4 telcos
	CERTH	• Participation at WP4 telcos • Contribution to the indicative queries and query requirements of ARIBFA, PWMA Residents' app
	UPM	• Participation at WP4 telcos
	SUITE5	• Alignment and integration points between the BICE, BSM and BIQB • Contribution to the technology selection, design and testing of BIQB • Integration activities with BSM and BICE • Definition of indicative queries for BICA • Review of D4.8
	XYLEM	• Participation at WP4 telcos • Contribution of indicative queries for RenoDSS • Review of D4.8
	UEDIN	• Contributed to Query Examples and materials database access

2.4.2.4 WP DELIVERABLES

Table 19 reports the status of the deliverables foreseen for WP4 during the first reporting period. For each deliverable, its title, lead beneficiary, due date and submission date are reported.

Table 19 WP4 deliverables status related to the 1st Reporting Period

Deliverable	Lead	Due	Status
D4.1 - Report on Semantic Alignment & Linking of EEB-related Ontologies	UPM	M10	Submitted in M10
D4.2 - BIMERR Ontology & Data Model 1	UPM	M15	Submitted in M15
D4.4 - BIMERR Building Semantic Modelling tool 1	SUITE5	M16	Documentation submitted in M17
D4.6 - BIMERR Information Collection & Enrichment Tool 1	SUITE5	M16	Documentation submitted in M17
D4.8 - Integrated BIMERR Interoperability Framework 1	UBITECH	M18	Documentation submitted in M18

2.4.2.5 WP MILESTONES

According to the official milestones in the DoA, there is no explicit milestone associated with WP4 in the first reporting period. However, the release of the draft integrated BIF platform as

planned on M18 is considered as a significant milestone for the ongoing WP4 activities and as such, it is reported in the following table.

Table 20 WP4 Milestones status related to the 1st Reporting Period

Milestone	Lead	Due	Status
Release of the initial, integrated BIF	Suite5	M18	Unofficial milestone – met in M18

2.4.3 WP Plans for the next Reporting Period

In the following period, Tasks T4.2-T4.6 will be constantly active, and a number of planned activities are expected as reported in the following table.

Table 21 WP4 plans for next reporting period

Task	Planned Activities Description
T4.1	This task ended in M10
T4.2	• Continuous enrichments and updates of the published BIMERR ontologies and data models that underpin the BIF deployment. Particular emphasis will be paid on the Building, Material Properties, and Renovation Measures domains. • Consolidation and delivery of the final BIMERR ontologies and data models in D4.3.
T4.3	• Constant updates of the Building Semantic Modelling component based on the preliminary feedback by the BIMERR applications that are currently under development. • Delivery of the final release of the Building Semantic Modelling component in M30 including a number of features and extensions of its subcomponents (i.e. a number of indicative functionalities that have been already planned are reported in D4.4). Documentation of the final BSM release in D4.5.
T4.4	• Constant updates of the Building Information Collection and Enrichment component based on the preliminary feedback by the BIMERR applications that are currently under development. • Delivery of the final release of the Building Information Collection and Enrichment component in M30 including a number of features and extensions of its subcomponents (i.e. a number of indicative functionalities that have been already planned are reported in D4.6). Documentation of the final BICE release in D4.7.
T4.5	• Constant updates of the Building Information Secure Provisioning component based on the preliminary feedback by the BIMERR applications that are currently under development. • Delivery of the final release of the Building Information Secure Provisioning component in M30 including a number of features extensions of its subcomponents (i.e. a number of indicative functionalities that have been already planned are reported in D4.8). Documentation of the final BISP release in D4.9.

Task	Planned Activities Description
T4.6	• Constant updates of the Building Information Query Builder component based on the preliminary feedback by the BIMERR applications that are currently under development. • Delivery of the final release of the Building Information Query Builder component in M30 including a number of features extensions of its subcomponents (i.e. a number of indicative functionalities that have been already planned are reported in D4.8). Documentation of the final BIQB release in D4.9.

2.4.4 COVID-19 Impact

N/A

2.5 WP5 - As-is Building Information Extraction & Model Population Tools

2.5.1 Summary of the WP objectives

The main objectives of WP5 are:

1. To extend and maintain a BIM platform that will support the BIMERR system with information about the building properties and construction methods/processes;
2. To enable the automated annotation and population of data models with extended information about the buildings;
3. To design & develop innovative hardware (e.g. AR Smart Glasses) and software (e.g. Scan-to-BIM and apps) tools that allow various stakeholders – e.g. surveyors, residents, AEC;
4. To create and share digital models of the exiting building;
5. To automatically infer the usage patterns of major energy-hungry building loads based on resident comfort preferences;
6. To identify opportunities for synergistic improvement of models and embed the needed functionalities accordingly in the various tools.

WP5 consisted initially of 6 tasks which aim to achieve the above-mentioned objectives:

- **T5.1 BIM Platform Adaptation for Efficient Renovation Support (M10-M30):** The purpose of this task is to support the BIMERR ICT system by providing key functionalities that enable existing BIM perspective and standards (e.g. IFC, COBie, CityGML) while also looking into providing extensions to facilitate information exchange with the other project tools, namely on semantic alignment in terms of building and process

information, data model & ontology extensions, etc. The platform also aims to become a testbed for extensions to existing standards (e.g. IFC) that will be proposed and developed during the project, to facilitate their testing and validation ahead of promotion to standardization bodies.

- **T5.2 Enhanced Scan-to-BIM Tools for Topology Reconstruction (M10-M30):** The purpose of this task is to generate the necessary Scan-to-BIM tools for the creation of the digital building model from reality capture data by extending existing scan-to-BIM tools (and scan-vs-BIM tools, when applicable) toward automated generation of the BIM model from colour point clouds (typically obtained via laser scanning) with a special emphasis on building characteristics that directly impact its energy consumption.
- **T5.3 Building Information Collection Application (BICA) for Building Residents (M10-M30):** The purpose of the T5.3 activities is to deliver an intuitive smartphone application that facilitates the residents in reporting a variety of building information that is essential for the design of a building renovation project. Such information shall be provided to the BIF via the BICA APIs on a scheduled basis and become available for the rest of the BIMERR applications through the BIF.
- **T5.4 Profiling Residents Usage of Building Systems (PRUBS) (M10-M30):** This task aims to provide information about the actual building usage patterns that should be expected post-renovation through human-centric behavioural profiling of indoor environmental conditions via Internet-of-Things solutions. Using a sensor network that will be designed and installed either in the form of physical sensors deployed in the building or as sensing apps using sensors of smartphone devices the goal is to capture the indoor environmental conditions in the building and then using a behavioural profiling engine to infer the comfort preferences of residents from the contextual conditions, the resident actions upon key building loads and other parameters. These parameters will be used to project the building system (e.g. heating/cooling) utilization boundaries that lie within the comfort zone of the residents so as to estimate the post-renovation energy consumption range.
- **T5.5 Refinement of Augmented-Reality Smart Glasses for the ARIBFA app (M12-M30):** This task involves the generation of the necessary hardware – smart glasses with all the necessary sensors and AR capabilities – for the BIMERR Augmented-Reality enabled building feature annotation application to populate digital models with building premises features. **(This task was merged with T5.6 below)**

- **T5.6 Software Design & Development for the ARIBFA app (M12-M30):** The purpose of this task is to deliver the software to enable on-site Augmented Reality Survey, annotation and monitoring in a renovation project through the use of 3D BIM models. The system consists of several sub-modules: the BIM 3D Model Registration and Tracking Module, the Indoor Localization Module, the Marker-less Feature Recognition and the AR Annotation & Context Aware-Visualisation. Integration of the software platform with Microsoft Hololens HMDs was included in the scope of this task after merging with T5.5.

2.5.2 Description of WP work during the Reporting Period

2.5.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

Table 22 reports relevant deviations with respect to the original WP plan as foreseen in the DoA.

Table 22 WP5's deviations description

Problem Description	Corrective actions undertaken by partners
EXE officially left the consortium due to bankruptcy. This led to a delay in activities in T5.1 which remained leaderless for 8 months.	• Project Amendment was made to switch delivery of D5.1 from M20 to M23 • Contingency Plan was agreed upon in the Limassol Plenary meeting in April 2020 to enable task activities that rely upon BIM Management platform to proceed the work in the interim until a new partner was found • UCL was inducted in the BIMERR consortium to take over leadership of T5.1 from 1/6/2020
GU was terminated, leaving WP5 and T5.5 without a lead partner	• On M8, we started developing a plan to mitigate the risk, replace missing technologies, and distribute workload among remaining partners, in accordance with the risk strategy • WP5 leadership was transferred to CERTH • T5.5 was merged with T5.6 since no new hardware was to be developed and Microsoft Hololens was selected as the AR HMD to integrate ARIBFA to • Some PMs from Task 5.5 were transferred to T5.6 to support activities to adapt ARIBFA to Hololens instead of GU Smart Glasses
T5.2 - Inadequate Scan+BIM software platform:	UEDIN has initiated the creation of an adequate and free Scan+BIM software platform using existing open

The main deviation is not for the reporting period per se but for the scope of work. Early in the project the UEDIN team identified a need to develop an open software platform that is able to handle both reality capture data – in particular point clouds and images (at large scale) – as well as BIM data, with all this data inputted and outputted in open formats (e.g. e57 for reality capture data and IFC for BIM data). While this activity was not explicitly defined in the DoA, it was found critical and received sustained focus.	source technologies. Progress towards building the Scan+BIM Software Platform is reported in Sections 1.4.2 and 2.5.2.2.

2.5.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

During the first reporting period, all the WP5 tasks have been active. Although all WP5 deliverables are planned to be submitted in the second reporting period, all tasks have shown progress, as briefly described below.

T5.1 BIM Platform Adaptation for Efficient Renovation Support: The work effort regarding the BIM Management platform according to the DoA was to begin in earnest in M10 but was considerably delayed due to the unfortunate effect of Task 5.1 remaining without a lead partner since EXERGY had been unresponsive in its responsibilities in the project since M9. The initial months (M10-M12) up until delivery of D3.5 (BIMERR System Architecture) where the high-level architecture of the BIM Management Platform would be defined, there was no clear feedback from EXERGY to confirm or deny if they would eventually leave the consortium. Therefore, it was decided that CERTH would unofficially take over as Task leader of T3.5 to define a preliminary system architecture and component definition for the BIM Management Platform based on the Task Description in the DoA.

Several online meetings were held between M10-M15 as well as slots were reserved in the two plenary face-to-face meetings within this period, in order to coordinate among all technical partners of the consortium and define the scope, requirements, interconnectivity and functionalities that the BIM Management Platform would support. However, a clear development plan could not be decided since no suitable existing partner of the consortium could take over the leadership of the task.

It was therefore decided to proceed with a contingency plan with two scenarios: 1) Find an external suitable partner to enter the consortium and take over leadership and activities for Task5.1 or 2) simplify the scope of T5.1, if such a new partner would not be found. In reality, due to the key role that the BIM Management Platform plays to support all tools in WP5 but also in WP6 tools and as part of the BIF of WP4, option 2 was considered early on to be avoided at all costs. To that effect, steps were taken to minimize the impact of the missing functionalities of the BIM Management platform in the other tools of WP5 by prioritizing development of functionalities of these tools that were independent of the existence of the BIM Management Platform. At the same time, the decision to postpone D5.1 (Prototype of enhanced BIM platform 1) to M23 since it was clear that absent a task leader for T5.1 the original M20 delivery was unattainable.

Throughout the period between M10-M15, multiple efforts were made by the project coordinator and the technical manager to get EXERGY back on track and to commit to the consortium and its project responsibilities. At the same time, contacts were made with Institutions that fulfilled the criteria of the technical and scientific expertise to potentially take over T5.1. Such a partner was identified in UCL with whom an initial agreement was made on M16 to enter the consortium but was officially ratified after acceptance of the project amendment by the EC on M17.

In the short time that UCL has officially entered the consortium in the beginning of M18, several discussions were held with UCL to get them up to speed with the project development so far and to bring T5.1 back on track by defining a clear implementation plan, prioritizing development of key functionalities to be delivered as planned in M23 and to proceed with the secondary functionalities for the second version of the platform for M30.

T5.2 Enhanced Scan-to-BIM Tools for Topology Reconstruction: The development of the Scan-to-BIM Tool has seen progress on three fronts: (1) the Scan+BIM Software Framework; (2) the Scan-to-BIM (Structural) Software Component; and (3) the Scan-to-BIM (MEP) Component. These are detailed in the following.

Scan+BIM Software Framework: Following a review of possible solutions, the UEDIN team selected to build a solution based on the Open Infra Platform (OIP) [1,2] and xBIM library [3,4. OIP provides a software framework and user interface for loading and navigating BIM data in IFC formats as well as reality capture data (through the use of the CloudCompare library). The

xBIM library is used solely for the generation of IFC models outputted by the Scan-to-BIM algorithm. This analysis and its outcome are reported in a conference paper submitted to ISARC 2020. Implementation of the proposed Scan+BIM platform solution is well progressed, and is estimated to be approximately 60% complete. It enables loading point clouds and IFC models, and will eventually run the Scan-to-BIM software components. The missing components principally include: some data navigation functionalities; and an IO plugin for importing photogrammetric data (i.e. point cloud, images and image calibration matrices) employed by UEDIN's Scan-to-BIM (MEP) component.

Scan-to-BIM (Structural) Component: The components include: (1) An algorithm for the automated detection of structural components (i.e. walls, floors, ceilings, doors and windows) in laser scanned point clouds and their modelling in IFC format; (2) A manual, UI-based tool for populating the material layers of those components. Our current V1 algorithm detects walls, floors and ceiling in standard basic environment (like most common dwellings). The algorithm does not detect openings yet. Regarding environment modelling, the algorithm currently outputs an IFC file that contains the above detected components as well as the 2LSB representation of that environment (required by RenoDSS) and ifcSpace objects delimiting each room (required by ARIBFA).

Scan-to-BIM (MEP) Component: The component is an algorithm for automatically detecting MEP components in photos of the indoor environment and add them to the IFC model of the environment initiated by the Scan-to-BIM (Structural) tool. Algorithms have been developed based on Faster R-CNN deep learning frameworks to detect sockets, switches and radiators using both 360 and normal images.

T5.3 Building Information Collection Application (BICA) for Building Residents: During the reporting period, the T5.3 activities focused on the iterative definition of the BICA functionalities, as well as on the design and specification activities. The preliminary functionalities of BICA were initially reported in D3.5, yet they have been slightly revised in alignment with the BIMERR applications' advancements in WP5, WP6 and WP7 (e.g. removing any potentially duplicate functionalities between BICA and PWMA Residents/Owners App). The user persona to which BICA is addressed has been described in order to derive its needs and consider its requirements and access barriers. The BICA data requirements have been also elaborated in collaboration with WP4 for the facilitation of the design of the relevant BIMERR ontologies and data models in the BIF.

The detailed BICA mockups, as well as a site map and a screen flow diagram (in the form of a wireflow), have been designed to effectively communicate the envisioned functionalities internally to the BIMERR consortium and guide the mobile development activities. A step-by-step demonstration of the BICA mockups took place in the 4th BIMERR plenary meeting that was held online in April 2020. The feedback acquired in terms of integration with other applications (e.g. PRUBS) through the BIF and of positioning in respect to the PWMA Residents/Owners application (that focuses on on-site works support in contrast to BICA that addresses the renovation design before the actual renovation starts) was extensively discussed and addressed.

T5.4 Profiling Residents Usage of Building Systems (PRUBS): During the first reporting period, two main sub-tasks (see section 1.4) have been running in parallel for the first version of the building resident energy related behaviour profiling framework's design and delivery on time (D5.7 to be issued on M22). An installation management plan, that consists of pre-installation and installation steps, has been drafted to ensure a smooth equipment installation process. Among the pre-installation steps, (1) the definition of PRUBS functional and input data requirements, (2) the preparation of the pilot site audit questionnaire, (3) the pilot site audits and reports, (3) the selection of IoT sensing and metering devices that meet the PRUBS input data requirements, and (4) the Wireless Sensor Topology definition and respective installation guidelines documentation have been completed due M18.

In parallel, a survey on existing Machine Learning algorithms and data models frequently used for occupant behaviour data extraction and representation has been performed. Candidate algorithms have been applied and tested on existing IoT data streams acquired by a WSN. For the occupant thermal comfort modelling, the Gaussian Naïve Bayes method has been implemented, a supervised Machine Learning (ML) algorithm that follows the Bayes' theorem assuming conditional independence between the features. To generate meaningful training events/datasets, requested by the aforementioned algorithm, certain pre-processing rules have been defined and programmed to be applied to sensed/metering data provided by the IoT streams data model (SenML). ObXML, an occupant behaviour data model and its schema definition, outcome of IEA-EBC Annex 66, has been analysed and selected as the output data model of PRUBS that includes data about the occupants' preferences and can be formulated as closed-form equations or as data-series so that they are compatible with the

BEP module requirements. A data transformation component that processes the Gaussian Naïve Bayes method results to automatically generate the obXML file is in progress.

T5.5 Refinement of Augmented-Reality Smart Glasses for the ARIBFA app: The task pertaining to the adaptation of the ARIBFA app for use on the HMD glasses that would be developed by GU was planned to begin activities in M12. However, GU stopped participating in project activities as early as M8 stating financial troubles, so the consortium GA agreed at the plenary meeting in Athens held on M12 to retire GU from the consortium and that T5.5 work would be shifted to support the Microsoft Hololens AR HMD instead. Since the majority of effort in T5.5 involved hardware development by GU that was no longer to be performed, it was decided that T5.5 would be merged with T5.6 and the remaining PMs of GU would be redistributed to the other partners and that CERTH would take over leadership of WP5 in place of GU.

The shift to Microsoft Hololens did not pose a great risk since CERTH had already extensive experience in developing apps and algorithms for the platform and since NT also planned to support Hololens in their PWMA for Workers app in WP6. Since the shift, CERTH began investigating and researching Hololens-specific methodologies for the four main sub-modules of ARIBFA: (1) BIM 3D Model Registration and Tracking; (2) Indoor localization; (3) Markerless feature recognition; (4) AR annotation & Context-Aware Visualization.

To that effect, key software components have already been developed and tested and are described below in the work of T5.6 for the period.

T5.6 Software Design & Development for the ARIBFA app: The main work conducted in Task 5.6 regards the development of the ARIBFA AR tool for on-the-field survey, monitoring and annotation of renovation projects. In the period covered by this report, the work conducted is separated into 5 subtasks:

- Microsoft Hololens HMD Integration of the 4 sub-modules outlined above (after T5.5 was merged to T5.6 as a result of GU exiting the project): Hololens-specific capabilities, restrictions and features have been identified and technical and functional specifications for all the sub-modules were defined based on them. Specific assumptions and decisions on the use of the BIM Management Platform were also made to account for the limited size of 3D BIM Models able to be displayed in real-time on a mobile device like Hololens.

Algorithms covering Registration and Tracking, Indoor Localization and Markerless Feature Recognition were also research according to their applicability using the on-board sensors in Hololens.

- BIM 3D Model Registration and Tracking: The effort in this subtask began with the SoA analysis and the identification of several research papers covering BIM model registration and tracking. This analysis provided promising results in the form of the papers included in section 1.4.7. Based on the literature, the next step in the ARIBFA development effort began with the development of an initial localization, registration and tracking system that makes use of the Hololens camera, depth sensors and IMU. Our approach followed closely the results of the research in [1] and the results show great promise already, using the integrated spatial mapping capabilities of the Hololens device. The initial registration of our system relies on image target acquisition and then continues tracking based on geometric feature mapping.
- Indoor localization: In this first period, indoors localization has been provided only through the visual registration and tracking methodology described in the previous sub-module. Since Hololens is lacking a GPS (for outdoors locations of a building) and visual registration alone can be problematic in some cases, we have identified in the literature hybrid methods that use IoT wireless signals and WiFi networks to provide an estimated location via triangulation. This can also be complimented outdoors using the GPS signal of a mobile phone that acts as a GPS server. Development on these methods will start in the upcoming period.
- Markerless feature recognition: The third sub-module under heavy development since M12 is the AR annotation of objects within a BIM model in real-time. To that end, a system using Yolo as a real-time object recognition library is under investigation and implementation on the Hololens device with support from an external processing server.

- AR annotation & Context-Aware Visualization: In the reporting period, work also began on the visualization of BIM models in IFC format within the Unity3D rendering engine. The problem with visualizing IFC models on real-time rendering engines is that BIM models are parametrically defined whereas real-time rendering requires polygon-based models. Several open-source solutions were identified and tested, however none provided 100% accurate visualization and/or mapping to IFC component parameters. The best of these involves the use of the ifCOpenShell library and was adopted and currently

under heavy modification through the creation of custom data structure for better 3D visualization and better mapping of object data to its geometry.

2.5.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Task	Partner	Activities performed in this period
T5.1	UCL	• UCL joined the project as T5.1 leader in M18. In the short time since then several bilateral and intra-WP discussions were held with UCL to proceed with the design, planning and development of the BIM Management Platform
	UEDIN	• Collaborated with FIT and CERTH to tackle the challenge of the partner EXE leaving the project prematurely.
	CERTH	• Definition of the initial architecture of the platform • Interim leadership of T5.1 until UCL joined • Organization of Online meetings to provide contingencies in place of the platform as a result of EXE exit • Investigation into possible external partners to take over the activity • Devise new time plan for delivery of BIM Management platform
	UPM	• Participation and Contribution in contingency planning after EXE exit
	CONKAT	• Participation and Contribution in contingency planning after EXE exit • Preparatory actions for participation in task execution and identification of possible role and contribution

T5.2	UEDIN	• Scan+BIM Software Framework:
		  ○ Selection of solutions
		  ○ Integration of all libraries of the selected solutions
		  ○ ISARC 2020 paper submitted.
		• Scan-to-BIM (Structural) Tool:
		  ○ Algorithms for detecting: walls, floors and ceiling (80%)
		  ○ Environment modelling: algorithm outputs an IFC file that contains the above-detected components as well as the 2nd-level space boundaries representation of that environment and ifcSpace objects. (80%)
		• Scan-to-BIM (MEP) Tool:
		  ○ Data collection for sockets, switches and radiators (50%)
		  ○ Algorithm selection from literature review (100%)
		  ○ V1 Faster R-CNN –based algorithms 7for detecting: sockets, switches and radiators using both 360 and standard images.

	XYLEM	• Participation in WP5 periodic online meetings
	UCL	• Participation in WP5 periodic online meetings
T5.3	Suite5	• Preliminary scope and functional requirements of the Building Information Collection Application (BICA) for residents • Specifications and initial mock-up design for the Building Information

		Collection Application (BICA) for residents
	HYPERTECH	• Participation in WP5 periodic online meetings
	BX	• Participation in WP5 periodic online meetings
	UOP	• Provision of photos for the image database of building MEP object • Participation in WP5 periodic online meetings
	UCL	• Participation in WP5 periodic online meetings
T5.4	HYPERTECH	• WSN installation management plan sketch • Definition of PRUBS functional and input data requirements • Preparation of the pilot site audit questionnaire • Selection of IoT sensing and metering devices • WSN Topology definition • Survey on existing Machine Learning algorithms and data models for occupant behaviour data extraction and representation • Existing ML algorithms evaluation and selection • Design and programming of pre-processing rules for events generation • PRUBS output data model selection • Design and development of an automated output data model population component
	UOP	• WSN installation management plan sketch • Preparation of the pilot site audit questionnaire • Selection of IoT sensing and metering devices • WSN Topology definition • First version of the WSN installation guidelines
	CONKAT	• Analysis of CONKAT's pre-validation building data to support WSN Topology definition • Completion of the pilot site audit questionnaire
	UPM	• PRUBS data modelling and exchange needs in collaboration with WP4 • Occupant behaviour data schema extension and updates for occupancy behaviour ontology
	BX	• Analysis of the Polish validation site data to support WSN Topology definition • Completion of the pilot site audit questionnaire
	FER	• Analysis of the Spanish validation site data to support WSN Topology definition • Completion of the pilot site audit questionnaire
T5.5	CERTH	**Task merged with T5.6 on M17** • Exploration of Hololens capabilities in spatial mapping, • Exploration of Hololens registration of 3D models in space • Early prototype implementation of multimodal AR UI • Set up weekly discussions within WP5 and WP6 partners to gather requirements, steer efforts and monitor development

	NT	• Discussions within WP5 and WP6 about AR requirements
T5.6	CERTH	• Development on the Indoors Localization sub-component based on visual registration • Development on IFC BIM model visualisation module in Unity3D • Development on 3D model registration on Hololens devices • Development on real-time Object recognition methodologies on mobile HMD • Organization of weekly or bi-weekly discussions within WP5 and WP6 partners to gather requirements, steer efforts and monitor development
	FIT	• Work on a style guide and design guidelines to align the visual appearance of the BIMERR end-user applications • Analysis of several existing style guides and design frameworks for cross-device application design • Organizing and hosting telcos for alignment discussions • Support with provided material (wireframes, mockups) to partners for alignment with the style guide draft • State of the Art analysis, focus on existing design guidelines and tools for AR/MR systems
	UEDIN	• Bilateral discussions with CERTH to streamline developments between the Scan-to-BIM Tool and the ARIBFA Tool (particularly following the premature departure of GU from the project).
	CONKAT	• Participation in WP5 online Meetings

2.5.2.4 WP DELIVERABLES

No WP5 deliverables due in first reporting period.

2.5.2.5 WP MILESTONES

No WP5 milestones due in first reporting period.

2.5.3 WP Plans for the next Reporting Period

Task	Planned Activities Description
T5.1	• Design the overall architecture of the BIM management platform and the interconnections with other BIMMER components. • Prioritization of the APIs' definition, depending on the BIMMER operational requirements. • Initialization of the development of the BIM management platforms core components: • IFC-SPF serialization/deserialization. • IFC versioning, optimizer and plugins

	• IFC data quality checking (correctness, completeness, schema compatibility), data enrichment. • IFC query API, graphical API (OBJ, glTF). • Ensure IFC models from the Scan-to-BIM framework are correctly read and managed by the BIM Platform. • Contribution in requirements definition, specifications and communication of BIM data to external applications • Integration of BIM Management Platform and ARIBFA • Integration of BIM Management Platform and PWMA App for residents • Modifications of the occupancy behaviour ontology according to the action models defined by PRUBS • Contribution from the scope of the final user
T5.2	• Scan+BIM Framework: Complete, i.e.: • Complete UI functionalities • Functionality to important all data from photogrammetric process output. • Scan-to-BIM (Structural) Framework: Complete, i.e.: • Opening detection • Investigation of more robust algorithms, for wall detection in particular. • UI functionality to add/edit component material layers. • Refine algorithm for the generation of ifcSpaces and 2nd-level space boundaries in complex environments • Scan-to-BIM (MEP) Framework: Complete, i.e.: • Develop algorithm for the detection of air conditioning units. • Complete construction of datasets for all selected MEP components. • Fine-tuning of R-CNN algorithms. • Modelling of detections in IFC. • Delivery of D5.3. • Delivery of D5.4
T5.3	• Development and delivery of the beta BICA application internally to the consortium for beta testing • Upload the BICA mobile app in the respective app store (i.e. Google Play Store) • Delivery of D5.5 on M22 and D5.6 on M30
T5.4	• Procurement of sensors for the CONKAT pre-validation site and the validation-sites • Selection of the flats for monitoring • Proceed with the WSN installation in the pre-validation and validation sites • Delivery of the first version of PRUBS to support the pre-validation deployment and testing activities (D5.7 – M22) • Delivery of PRUBS updated/final version to evaluate their performance in real renovation projects (D5.8 – M30).
T5.6	• Organization of weekly or bi-weekly discussions within WP5 and WP6 partners to gather requirements, steer efforts and monitor development • Further development and optimization on the Indoors Localization sub-component based on visual registration • Further development and optimization on IFC BIM model visualisation module in Unity3D • Further development and optimization on 3D model registration on Hololens

	devices • Further development and optimization on real-time Object recognition methodologies on mobile HMD • Integration of BIM Management Platform with ARIBFA • Testing of ARIBFA in pre-validation and pilot sites • Continue streamlining of activities (and sharing of tools) with CERTH • Continue working on a style guide and design guidelines to align the visual appearance of the BIMERR end-user application • Organizing Ui alignment calls and actions • Continue SOTA analysis, focus on existing design guidelines and tools for AR/MR systems • Investigate in rapid prototyping methods and tools • Supporting UI developing partners on their request • Contribution form the scope of the final user • Delivery of D5.9, D5.10

2.5.4 COVID-19 Impact

Some activities regarding pre-validation and testing of WP5 related technologies in physical locations have been mildly affected due to the restrictions but are already back on track.

Most partners implemented a work-from-home scheme since March 2020, many have now resumed normal operations or have decided for a partial scheme where employees are some days at the office and some days working from home, so that the impact of COVID-19 is expected to be lower in the following period of the project.

2.6 WP6 - PROCESS MANAGEMENT TOOLS & END- USER APPS FOR ON-SITE STAKEHOLDERS

2.6.1 Summary of the WP objectives

This work package extracts knowledge to **understand the renovation process** from conception to delivery, extract opportunities to develop a digital twin by creating flexible process models that enable the renovation designer/planner to optimally schedule and simulate jobs based on custom objective functions. This is targeted in Task 6.2 and Task 6.3.

To refine and re-purpose powerful **process automation and workflow management** tools for the construction domain in order to link the digital twin – consisting of workflow log files, additional data form legacy systems and accessing the BIMMER Integration Framework - into the real-world, hence simulated processes become real world processes. The realisation is

performed by interacting with the workers either by project planning tools, other legacy devices or novel mobile apps and HoloLenses.

To create tools for **process simulation to estimate the impact of unpredictable factors**. Based on the extracted knowledge of renovation processes and their possible risks, an advanced simulation is developed that considers the knowledge base and hence better predict critical phases of the renovation process. Formal verification is provided to assist the transformation from renovation process to executable workflow and complex dependency analysis for the log-files, additional documents and knowledge bases of the renovation process is provided, as the basis for a digital twin from the renovation process.

To create a **cross-layer monitoring framework** evaluating close to real-time and simulated alternative process options so as to optimize cost, time, disruption, etc. in a continuous and – with respect to decision support – real time[11] manner. This means that pure data like working or machine hours as well as material are equally monitored as knowledge like quality of work and progress status interpretation as well as abstract goals like quality, trust or project strategy.

2.6.2 Description of WP work during the Reporting Period

2.6.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

Problem Description	Corrective actions undertaken by partners
GlassUp left the project	CERTH took over responsibilities and effort

2.6.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

The work package deals with the implementation of the PWMA environment that is explained in section 1.4.2.5, and started in M5 on time and is now finishing with the first iteration.

T6.1 Renovation Process Analysis & Tools Specification Definition

[11] Real-time is a difficult term, here we interpret the real-time character in the time slot the information needed, for decision support this typically ranges from minutes to hours, days, weeks or month.

This task analyses the renovation activities from a process perspective and identify the various tasks, work items and stakeholders involved as well as what information will be exchanged in the BIMERR context to enable better collaboration and project/process management. This was achieved by applying design thinking methods during a partner meeting in order to extract a common understanding on renovation processes, identify the phases of the renovation process, indicated where tool support is feasible and work-out a high-level application scenario for the PWMA.

Primary research will be performed based on input from all relevant stakeholders (architects, workers, project managers, occupants, etc.) to obtain a thorough understanding of the renovation process from the very initial phase of the process to the very end and what type of tools the stakeholders themselves believe are more useful to facilitate a more efficient, faster, cheaper and less disruptive renovation process.

In a second step, the concrete specifications of the software tools required to fully support the stakeholders during the renovation process were defined, focusing on the necessary adaptations of existing tools (e.g. ADOxx of BOC for process modelling and simulation and NT's I3D platform) as well as integration issues among these tools.

The task ended with D6.1 (M13) introducing high level application scenarios.

T6.2 Adaptive Process/Workflow Modelling and Mapping to the Interoperability Framework

This task, defines both the renovation (business and operational) process model as well as the workflow model based on the requirements including all the steps from the very beginning of the process to the delivery of the renovated building to the residents/owners. The difference between business process models and workflow models is the level of technical detail as well as the level of abstraction. This means that business processes can be interpreted by human experts whereas workflows can be interpreted by software.

We need to model all interactions between the various tools and actors of the process and workflow in order to obtain the necessary information at both abstraction levels for the process simulation and workflow automation work of the following tasks. Here, models are considered as externalization of knowledge, hence the challenge is to use the appropriate modelling notation to best store the knowledge for the intendent purpose – e.g. simulation,

execution, - and for the intendent interpretation – e.g. human interpretation, software interpretation. The challenge is to divide the domain complexity into business processes and technical complexity into workflows. For example, information includes stakeholder interactions and digital files that must be exchanged to facilitate an efficient progress of the renovation design, planning and works. In this case the semantic and domain relevant relations are captured in the business process, the interfaces and file formats in the workflow. The model must be parametric and flexible to allow for the investigation of various options in order to identify feasible ways to optimize the process overall in terms of scheduling or work item characteristics. This is necessary to introduce a common semantic in the digital twin and across the different applications along the renovation process. Currently a "loose coupling" approach is used, which may be exchanged by a "semantic lifting" approach. An important step of this task will be to understand, design and map the interactions which will be mediated by the interoperability framework that will be responsible for the semantic and syntactic coherency of exchanged information.

Task 6.2 created the first renovation process models – in form of templates - according to the identified requested support in D6.2 (M16). The practical use, especially the transformation from business process to workflow and the corresponding interaction challenges, are foreseen for the second iteration that will have D6.3 (M30) as an outcome.

T6.3 Renovation Process Simulation and Formal Verification

This task provides the full-fledged modelling infrastructure to support the renovation process modelling, analysis, verification, simulation and the interaction with workflow execution, process mining or collaboration platforms. It develops a specific open-source module - using the open source Micro-Service Framework OLIVE - of the process management toolkit that will simulate and formal verify the process of the designed renovation to allow the user to identify process steps or interactions that are critical for the successful implementation of the project.

The exploration of optimization opportunities to minimize time and/or cost, optimize across activities by reorganizing activities, etc. is performed by using human knowledge providing a collaboration space for reflection as well as data analytics using state of the art process mining. Such mechanisms are employed to create a so-called digital twin that is used to simulate different alternatives. Complex dependencies need formally correct models,

otherwise mathematical algorithms cannot be applied. This task deals with the identification, development and integration of such algorithms in an open service framework to enable not only the generation of a digital twin, but also its use for simulation.

The original plan was that renovation process will be simulated step-by-step in time, showing interactions between different activities (e.g. procurement, logistics, warehousing, existing equipment/component removal, building preparation, installation of new equipment/components, finishing touches, waste/scrap removal from the site and recycling, etc.), contrasting this with contractor/worker availability, procurement schedules and material/component availability, etc. After analyzing the high-level application scenario described in D6.1, the stakeholder worked out that currently sufficient estimations can be performed by human experts, however monitoring and simulation support is appreciated during the execution phase of the project. Hence the simulation focused according the stakeholder request on time and cost simulation based on working time and costs, machine time and costs, duration time and cost, execution time and cost as well as material costs on the site.

This task realised the corresponding modelling, monitoring and simulation environment in D6.2 (M17) as well as a set of open use and open source components that can be downloaded from ADOxx.org and form the corresponding GitLab directory.

T6.4 Adaptive Workflow Management and Automation Module Configuration

This task delivers an adaptive workflow management tool that will orchestrate the renovation tasks and facilitate information exchange between them. Parts of the renovation process that are modelled in Task 6.2 can be executed automatically using a workflow engine. Those parts are received by the modelling environment provided in Task 6.3 in order to perform the resource allocation.

It will further enable stakeholders to keep track of the entire process at real-time as well as automated reporting and adaptation of the workflow in case of planned or unforeseen developments during the renovation process. The mechanisms to introduce flexibility and adaptability will be worked out in the second iteration. Adaptiveness is necessary to account for unexpected effects, such as weather patterns that may prohibit specific works or worker unavailability due to sickness, etc. The first activity of this task is the definition and

implementation of the concrete, executable workflow based on the stakeholder requirements in terms of renovation process analysis from Task 6.2. Based on the specifications, the required extensions and configurations to the workflow management and automation module in the direction of interfacing with applications for on-site works to enable an automated monitoring – and therefore the creation of a digital twin - and reporting of the renovation works will be defined and implemented.

Task 6.4 realises the initial workflow execution environment in D6.6 (M19), that describes the modelled renovation processes in the form of workflows that interact with the BIMERR tools. The adaptiveness and integration will be empowered in the second iteration in D6.7 (M30).

T6.5 Apps for On-site works support and BIM update based on as-built information

This task will develop apps to support stakeholders during the renovation works: one app for building residents/owners and a second one for construction workers.

The smartphone app for residents will aim to inform them about ongoing works including planning modification due to real conditions on the work site (e.g. weather conditions prohibiting specific works), draw their attention to potential hazards due to these works, request their involvement in specific activities (e.g. technicians may require their input in selection or placement of components), allow them to negotiate and schedule meetings with contractors/technicians, etc.

The app for construction workers (applications for smart-glasses) will aim to provide in-the-field guidance on several fronts: e.g. to alert them to hazardous components, assist them in reporting work progress (which will be automatically synchronised across BIMERR tools to provide all stakeholders an up-to-date view on activities and actual progress), guide them in the process of installation/assembly based on vendor information, etc. This tool will be based on the I3D platform of NT which will be adapted accordingly. The on-site guidance apps will be based on the I3D platform of NT and it will support the porting to the smart glasses. CERTH will create the apps for residents.

During this reporting period work on the application for residents involved the technical and functional requirements definition for the mobile application based on the use cases defined in T3.1, the preliminary design of the user interface and interaction based on the identified

requirements and the coordination among this task and other tasks involving end-user-oriented UIs so that the look and feel of the application is consistent among all BIMERR UIs.

Furthermore, preliminary work has begun to integrate the back-end functionalities of the PWMA platform, in order to provide user notifications for health and safety issues arising from tasks scheduled in the vicinity of the user, monitoring progress based on real-time project updates and to provide feedback from the user regarding issues pertaining to specific task implementation in the building.

2.6.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Task	Partner	Activities performed in this period
T6.1	BOC	• WP6 Kick-Off, WP6 telcos, participation and contribution to partner meetings, participation and contribution to status meetings • Stakeholder Contribution via Scene2Model on Renovation Process • BIMERR System Architecture and reflection to WP6 according requirements and capabilities of Digital Twin • Identification of data needs, sources, and interfaces of PWMA • Microservice Development and Deployment Architecture and experiments with IoT sensor prototypes • Research and survey on relevant tools and approaches • D6.1, setup, contribution, writing, reviewing and finalisation
	CONKAT	• Participation in teleconferences, in collaboration with other pilot partners and the task leader targeting to provide contribution from the scope of the final user (construction industry) for the renovation process analysis and workflow
	NT	• Participation in the workshops during partner meeting • D6.1 contribution
	BX	• Participation in the workshops during partner meeting • Contributing to the overall phases of renovation processes • D6.1 contribution
	FER	• Participation in the workshops during partner meeting • D6.1 contribution
T6.2	BOC	• WP6 telcos, participation and contribution to partner meetings, participation and contribution to status meetings • Setup process modelling workshops with end users BX, CONCAT, FER • Renovation Process Modelling with BX, CONCAT, FER identifying templates, modelling templates and instantiating sample workflows • Development of Simulation Algorithms for knowledge-based Discrete Event Simulation with variable properties per token • Development of Monitoring KPIs based on cost and time as well as trustworthiness characteristics • Development of management approach for Digital Twin of renovation

		process • D6.2, setup, contribution, writing, reviewing and finalisation
	SUITE5	• Continuous discussions on the interactions of the Adaptive Renovation Process & Workflow Models with the BIF • Review of D6.2
	UBITECH	• Activities for alignment of the BISP with the Adaptive Process/Workflow Modelling
	UPM	• Internal communication about PWMA data modelling and exchange needs in collaboration with WP4. • Participation in telcos about PWMA data needs
	FER	• Assistance to BOC in the framework of several telcos in order to establish the ground material and knowledge on which parts 5 and 6 of the deliverable D6.2 are based • Review of D6.2
	NT	• Started discussion about the data and information needed to be exchanged via BIF between several BIMERR tools. • Internal review and Contribution to D6.2.
	CONKAT	• Participation in teleconferences, in collaboration with other pilot partners and the task leader targeting to provide contribution from the scope of the final user (construction industry) for the renovation process analysis and workflow
T6.3	BOC	• WP6 telcos, participation and contribution to partner meetings, participation and contribution to status meetings • Conceptualisation of architecture, service interfaces and tools • Prototype Implementation of Simulation Algorithms for knowledge-based Discrete Event Simulation with variable properties per token • Prototype Implementation of Monitoring KPIs based on cost and time as well as trustworthiness characteristics • Prototype Implementation of collaboration space for reflection using XWIKI • Integration of prototypes using Microservice Framework OLIVE • Prototype Implementation of Connectors to Workflow Engine Activiti and Process Mining Tool Zelonis • D6.4, setup, contribution, writing, reviewing and finalisation
	SUITE5	• Integration of the Renovation Process Simulation Tool with the BIF • Contribution to D6.4
	NT	• Contribution to D6.4 • Internal review of D6.4
T6.4	NT	• Development of the adaptive workflow execution tool for the Project manager to follow and manage the reconstruction process. • Exchanging business process models with design environment of PWMA • Initial notification with resident apps
T6.5	CERTH	• Participation in WP6 online meetings • Development of PWMA Residents app • preliminary design of the user interface and interaction

		• technical and functional requirements definition for the mobile application • Preliminary work to integrate the back-end functionalities of the PWMA platform, • Internal review of D6.4
	FER	• Assistance to CERTH and NT in order to establish the requirements for the Resident and Workers Apps
	NT	• Coordination of development of end-user apps. • Collecting specifications to end-user applications. • Development of application for on-site support of workers

2.6.2.4 WP DELIVERABLES

Deliverable	Lead	Due	Status
D6.1 – Report on process/workflow management tools for renovation support	BOC	M13	Submitted M13
D6.2 – Adaptive renovation process & workflow models 1	BOC	M16	Submitted M17
D6.4 – Renovation process simulation tools 1	BOC	M18	Submitted M18

2.6.2.5 WP MILESTONES

No WP6 milestones due in first reporting period.

2.6.3 WP Plans for the next Reporting Period

Task	Planned Activities Description
T6.1	• This task ended in M13
T6.2	• Second iteration on renovation process models by supporting the transformation from template to concrete renovation process and extending the process model for stakeholders needs
T6.3	• Second iteration on the renovation process modelling and simulation tools to provide the corresponding tool capabilities. Better simulation, analysis and monitoring features for the digital twin of the renovation process.
T6.4	• Second iteration of adaptive workflow engine, introducing adaptivity, a better integration with smart glasses and apps as well as provision of log files to create a digital twin of the renovation process.

T6.5	• Second iteration of resident app and integration with workflow engine, BISP and Apps for onsite work.

2.6.4 COVID-19 Impact

WP6 was influenced by COVID-19 in the phase of compiling the deliverables for the initial prototypes. The coordination between partners was established in a series of virtual meetings, which are planned to continue. This had no negative impact. The tasks are separated in such a way, that software developers can develop mainly within one task and minor integration between tasks is necessary. In case of the mobile apps and the workflow engine, this integration is solved by typical mechanisms of distributed software engineering.

The strongest negative impact was that key personnel - especially from SMEs - were confronted with extreme crisis management tasks in their enterprises, including shortening of working time of team members and other cost cutting issues. This negatively affected the progress of work in the months April and May causing some difficulties and delays.

Due to the current recovery and the installment of the crisis management, WP6 may have some minor delays in the summer period, but will recover during fall 2020.

For the time ahead, we do not see major effects for WP6 in case the COVID-19 situation continues to recover. A quarterly assessment is introduced starting in Q3 in 2020 to assess the status of the partners.

2.7 WP7 - RENOVATION DECISION SUPPORT SYSTEM

2.7.1 Summary of the WP objectives

The main objectives of WP7 are to:

1. To design and develop the Renovation Decision Support System (RenoDSS), including the front-end and core engine as well as the dedicated modules for the accurate estimation/projection of the building Life Cycle impact on sustainability and economics, energy consumption and district/urban planning.
2. To obtain - and create whenever necessary – databases with component and material properties to support the operation of renovation design and support tools.

WP7 consists of five tasks which aim to achieve the above-mentioned objectives:

- **Task 7.1 – Building Components Database Design & Development (M6-M30)**: The goal of this task is to collect the information requirements from the related tasks (T3.5 & WP7 tasks) about the required information per type of building material, system or component and in a second phase design the database schema and populate it accordingly based on information published by vendors.
- **Task 7.2 – Renovation LCA/LCC Module (M8-M30):** This task will design and develop the DSS module that will be responsible for the Life Cycle Cost/Assessment of the various renovation options that will be explored by the tool user. It will effectively be a calculation engine that retrieves information about the renovation components/ materials based on the renovation scenario under design as well as the project post-renovation energy consumption in order to initially provide an estimation of the required up-front investment, the expected economic benefits due to the renovation and estimation of sustainability impact.
- **Task 7.3 – Building Energy Performance Modelling Module (M9-M30)**: This task aims to develop the module of the Renovation DSS that will be responsible for estimating the building energy consumption before and after the renovation interventions under examination. It will enable the DSS user to explore various what-if scenarios, quickly run energy models (or simulations) to estimate the energy savings and fine-tune the interventions to explore the trade-offs.
- **Task 7.4 – Urban Planning Module (M9-M30)**: The purpose of this task is to create and deliver the Urban Planning module. This module will provide the geographical perspective of the building under renovation, how it fits in its surroundings, detailed information about its energy use patterns and how it interacts with utility networks in its vicinity.
- **Task 7.5 – Decision Support System Engine & Module Integration (M9-M30)**: The main aim of this task is to develop RenoDSS and put forward an intuitive and easy-to-use interface that illustrates the renovation options, evaluates their impact on the building performance and guides through various alternatives towards the optimal choice for given boundary constraints (such as size of intervention, budget, target energy savings, etc.).

2.7.2 Description of WP work during the Reporting Period

2.7.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

Table 23 reports relevant deviations with respect to the original WP plan as foreseen in the DoA.

Table 23 WP7's deviations description

Problem Description	Corrective actions undertaken by partners
EXE left the project. The work has not been conducted on T7.1 as planned. D7.1 cannot be submitted on time (M13).	XYLEM took over the leadership and work of T7.1. Deliverable D7.1 will be delayed and will be submitted in M20.

2.7.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

No deliverables were due in the first reporting period. WP work during the reporting period includes:

T7.1 – Building Components Database Design & Development: T7.1 has shown progress that is summarized as follows:

- Development of requirements questionnaire and sharing to relevant partners
- Design of building material and component database schema
- Identification and mapping of third-party material and component input data sources (baubook, ökobaudat, and ashrae)
- Development and implementation of material and component classification tree
- Implementation of a first version BIMERR Material and Component Database based on state-of-the-art technologies and three layers: (1) The Presentation Layer, containing the endpoint through which BIMERR applications can retrieve the data and the administration user interface which allows the user to set data retrieval preferences. The REST interface is hosted by Apache Tomcat, the user interface is built upon Angular, Typescript, and NGRX Entity/Store. (2) The Business Logic Layer which transforms and harmonizes the data according to the user's preferences is written in Java. (3) The Data Layer that utilizes PostgreSQL to store the actual building material and component data.

T7.2 – Renovation LCA/LCC Module: The BIMERR LCA/LCC module is based on state-of-the-art technologies and three layers: The Presentation Layer, which allows the user to set

his/her preferred data sources for sustainability data and project-specific financial data. The user interface is built upon Angular, Typescript, and NGRX Entity/Store. The Business Logic Layer which calculates the KPIs based on the IFC file and the financial and sustainability data for the building materials used in the renovation scenario. The Data Layer that utilizes PostgreSQL to store preferred data sources, project-specific financial data, and calculated KPIs for faster access at later usage.

Within T7.2, the following activities have been completed:

- LCA and LCC method research;
- Definition of energy, economic, and sustainability KPIs;
- Design and implementation of renovation measure data model;
- Integration of xBim to extract IFC data.

T7.3 – Building Energy Performance Modelling module:

Within BIMERR, Industry Foundation Classes (IFC) files are used to streamline and expedite the collection of the building static information (building elements, materials and their thermal properties, HVAC components, to name but a few), while obXML files capture the dynamic data (schedules and thermal comfort preferences). A survey on existing BEP calculation methodologies that exploit both IFC and obXML data to automate the BEP models' generation has been performed, concluding to EnergyPlus as the BEP simulation engine to be used within BIMERR. Beyond a wide variety of EnergyPlus output parameters, specific variables can be reported based on the actual simulation problem described in the EnergyPlus Input Data File (IDF). The Report Data Dictionary (RDD) of EnergyPlus is a text file listing those variables for reporting during the simulation of a certain IDF. The energy KPIs that have been documented in D3.3 and the RDD file generated by a baseline simulation have been analysed to define the energy KPIs that need to and can be calculated by the BEP module. Results stemmed from the aforementioned analysis have been further processed to determine the BEP data requirements towards calculating the requested energy KPIs. In addition, a first version of the BEP module protype has been designed and developed, consisting of three main sub-components: IDF generator; BEP simulation; and BEP Manager. In alignment with the BIMERR architecture (D3.5), these sub-components collaborate to address the BEP module's scope. In summary, the BEP Manager, acts as the orchestrator of the BEP module. It receives scenarios evaluation requests from RenoDSS and triggers the IDF Generator. The IDF generator, collecting the building static (IFC), dynamic (obXML) and

weather (EPW) data, processes the content of the IFC file to generate the Input Data File of EnergyPlus simulation engine, while the co-simulation with the obXML, to take into account actual schedules based on data-driven occupant behavior models, is established, and submits a simulation request to the BEP simulation module. When the simulation is completed, outputs/report files are populated and sent to the BEP Manager to be further processed and populate a Json file with the KPIs that are sent back the RenoDSS. An initial version of interfaces has been released to start experimenting with the RenoDSS and the BEP module data exchange.

Since numerous candidate renovation scenarios evaluation requests are going to be sent in parallel, the use of asynchronous communication tools and highly scalable cluster computing techniques to distribute computations and to gather results are going to be investigated and implemented.

T7.4 – Urban Planning module: The BIMERR Urban Planning provides the geographical perspective of the building under renovation and its surrounding buildings, as well as detailed information about energy production/consumption patterns and how the building interacts with utility networks in its vicinity. The BIMERR Urban Planning module is based on state-of-the-art technologies and three layers: The Presentation Layer, which visualizes the energy flows and allows users to set their preferred data sources for energy production/consumption profiles of surrounding buildings. The user interface is built upon Angular, Typescript, and NGRX Entity/Store and uses Leaflet for visualizing the map view. The Business Logic Layer which is charge of calculating the KPIs and energy flows based on the stored production/consumption profiles of the renovation project and the surrounding buildings. This layer is based on Spring Boot and OpenJDK. Finally, the Data Layer utilizes PostgreSQL to store consumption/production profile data of the renovation project and surrounding buildings for faster access at later usage.

Within T7.4, the following activities have been carried out:

- Initial urban planning data model requirements conducted
- Urban planning data model requirements submitted
- Implementation of map view and building visualization
- Implementation of region- and usage-type-specific load profiles
- Implementation of the first version KPI calculation (energy excess profiles)

T7.5 – Decision Support System Engine and UI & Module Integration: The main aim of RenoDSS is to put forward an intuitive and easy-to-use interface that illustrates the renovation options, evaluates their impact on the building performance and guides the user through various alternatives towards the optimal choice for given boundary constraints (such as size of intervention, budget, target energy savings, etc.). RenoDSS will offer to the user a renovation configurator that will allow her to explore alternative renovation interventions. The following achievements can be reported within T7.5:

- RenoDSS UI design completed
- Setup of RenoDSS infrastructure and system completed
- Initial BEPE module (T7.3) communication implemented
- RenoDSS projects view completed
- RenoDSS building view started
- RenoDSS scenario view completed
- RenoDSS renovation measures admin view completed

2.7.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Table 24 provides details about the overall work by partners involved in WP7. The table inputs are collected by the WP7 Leader (XYLEM) incorporating information from the relevant partner's QMRs.

Table 24 WP7's work done by partners during the 1st Reporting Period

Task	Partner	Activities performed in this period
T7.1	EXE	• Content of the task and deliverable prepared and shared with the partners. • Task scope reviewed and work plan developed to achieve the objectives on time. • Survey/questionnaire developed and shared with the partners.
	XYLEM	• Contributed to the building components database design (questionnaire, document structure) • Building material database research (baubook, etc.) completed • Building component and material database model • Research on data translation concepts • Map building material classes from data sources to classification tree • Material classification tree completed • D7.1 writing started • DB endpoints implemented

		• Import ökobaudat and ashrae data
	FER	• The main contribution in this task was input given as response to EXERGY's Questionnaire about building materials components for the BIMERR • Provided input about building materials components for the BIMERR which include information about building regulations, envelope elements, sources for structural specification and databases • Provided feedback on the Energy and LCC/LCA KPIs definition. • Activities were undertaken to gather information about previous Building energy certification of the building,
	BX	• The main contribution in this task was input given as response to EXERGY's Questionnaire about building materials components for the BIMERR which include information about building regulations, envelope elements, sources for structural specification and databases. • Preparation of information on Polish construction law in the field of energy efficiency. • Analysis of partitions in a pilot building and energy audit from 2017. • Preparation of the questionnaire: Building materials components for the BIMERR.
	UPM	• Script for accessing oekobaudat files • start data structure analysis
T7.2	XYLEM	• T7.2 Kick-off telco organized and held on 06.09.2019 • Initial task planning organized and conducted • Research and consolidation on/of relevant KPIs completed • LCC method research completed • Renovation measures data model completed • Economic KPIs refined and documented • Sustainability KPIs refined and documented • D7.3 writing started • Implementation project-specific cost data • xBim integration to extract IFC data
	CERTH	• Data acquisition in Smart Home for LCA testing • Research on LCA methods in progress
T7.3	HYPERTECH	• T7.3 Kick-off telco held on 03.09.2019 • Participated and contributed to T7.3 Kick-off • Assign roles to the involved partners • Definition of detailed functionalities • Survey on existing BIM-to-BEP methodologies • BEP simulation engine selection and adoption • Research and definition of the Energy and Comfort KPIs to be calculated by the BEP module • Determination of the BEP input data requirements (first version) • Design and development of the first version of the BEPE module's prototype • High-level data exchange specifications with RenoDSS • D7.5 writing started

	CONKAT	• Participated and contributed to T7.3 Kick-off telco. • Identified as the partner responsible for preparation of simple demo buildings - start from box building with one building and add complexity over time. • Clarification of possible contribution in the framework of the task
	XYLEM	• T7.3 Kick-off organized and telco held on 03.09.2019 • Initial task planning organized and conducted
	MERIT	• Participated and contributed to T7.3 Kick-off telco. • Identified as Subtask leader for literature review of open-source Building Energy Modeling tools. • Offered to contribute by going through an evaluation of the results (e.g. explainable order of magnitude, energy demands and consumption decrease by applying renovation measures) and their sensitivity to domain-expertise parameters change (e.g. simulation timestep, heat balance algorithm etc.).
T7.4	XYLEM	• T7.4 Kick-off organized and telco held on 03.09.2019 • Initial task planning organized and conducted • Initial urban planning data model requirements conducted • Urban planning data model requirements submitted • Implementation map view and building visualization
	CONKAT	• Participated and contributed to T7.4 Kick-off telco. • Identification of the exact role in the task and preparation activities to accomplish it.
T7.5	XYLEM	• T7.5 Kick-off organized and telco held on 06.09.2019 • Initial task planning organized and conducted • Design RenoDSS UI completed • Setup RenoDSS infrastructure and system • Implement RenoDSS IFC parsing capabilities • Initial BEPE communication implemented • GUI planning scenario view completed • Implementation GUI scenario view completed • GUI planning renovation measures admin view completed • Implementation GUI renovation measures admin view completed • Implementation GUI projects view completed • IFC-measures mapping started
	CONKAT	• Participated and contributed to T7.5 Kick-off telco. • Identification of the exact role in the task and preparation activities to accomplish it. • Internal task activity evaluation and preparation of contribution from the scope of the final user.
	CERTH	• Participation in kick off online meeting • Data acquisition in Smart Home for DSS testing • Research on AI algorithms for energy efficiency DSS

2.7.2.4 WP DELIVERABLES

No WP7 deliverables due in first reporting period.

2.7.2.5 WP MILESTONES

No WP7 milestones due in the first reporting period.

2.7.3 WP Plans for the next Reporting Period

Table 25 summarizes the plans for the next period for each task.

Table 25 WP7 plans for next reporting period

Task	Planned Activities Description
T7.1	D7.1 due in M20 • Delivering first version of BIMERR material and component database
	D7.2 due in M30 • Extending the material data as required by the pre-validation and validation sites, especially the domains of windows, heating systems, and PV systems. • Prepare the database content for the validation and pre-validation activities (Task 8.1), i.e. adding materials if necessary. • Integrate the database into the BIF and allow the user to query it not only via the endpoint but also via the BIF. • Creating a generic material representation and mapping the available data sources to it. Research and development on semi-automated mapping approaches. • Enabling the user to select which data sources are used to populate the concrete values of the generic building materials in the context of a specific renovation project. • End user interface for manipulating generic BIMERR material data (global and project-specific values).
T7.2	D7.3 due in M20 • Delivering first version of BIMERR LCA/LCC module
	D7.4 due in M30 • To perform unit conversions, the IFC unit of measurement will be extracted from the IFC file. • Implementation of unit conversions to match IFC units with material units from the BIMERR Component and Material database. • Implementation of renovation scenario KPI calculation (e.g. life cycle cost). • Project-specific energy costs, interest rates, environmental costs, and CO2 emission rates based on region-specific global values which are maintained by the administrator role. • Evaluation if the integration of third-party approaches such as OpenLCA provide additional benefit to the RenoDSS user.

T7.3	D7.5 due in M20 • Delivering first version of BIMERR BEP module
	D7.6 due in M30 • Finalization of BEP module
T7.4	D7.7 due in M20 • Delivering first version of BIMERR Urban Planning module
	D7.8 due in M20 • Energy networks integration and visualization based on sample data • Convert sample Network data from pre-validation and validation sites to CityGML network representation • CityGML export functionality ensures that available network, energy mix and energy consumption/production data can be exported to a standardized data format. • Visualization of energy flows between renovation project and surrounding buildings assuming that energy always takes the shortest path. The paths show the direction of energy flows and are labelled with the annual energy exchange. By clicking on the path, the detailed production and consumption profiles of the two buildings are shown. To calculate the energy distribution to the surrounding buildings the hill climbing algorithm is used. • Visualization of excess energy on the district level: if there are no surrounding buildings to which excess energy can be exported an arrow to/from the neighbourhood is used to visualize a non-point source/target
T7.5	D7.9 due in M22 • Delivering first version of BIMERR RenoDSS
	D7.10 due in M20 • Design and implementation of scenario generator • Design and implementation of decision support functionality • BEP endpoint async communication

2.7.4 COVID-19 Impact

In the first reporting period, COVID did not affect the WP7 progress and no negative impact is expected for the remaining work in WP7. However, validating the WP7 results requires the availability of pre-validation and validation sites which are managed in WP8 and WP9.

2.8 WP8 - ICT System Integration, Testing & Pre-Validation

The main objectives of WP8 are to enable seamless information exchange between BIMERR ICT sub-systems by means of a secure middleware. The work package also involves realistic integration tests and pre-validation deployments of the system.

2.8.1 Summary of the WP objectives

WP8 consists of 4 tasks which aim to achieve the above-mentioned objectives:

- **Task 8.1 – External Information Availability & Sourcing (M4-M32):** this task involves the survey of existing information relevant to BIMERR such as interfaces, APIs to component and material databases or existing ICT systems. The necessary information will be stored in the databases of Task 7.1.
- **Task 8.2 – Design & configuration of Middleware for Information Exchange throughout Architecture (M10-M26):** this task includes the work on delivery of middleware for integration of BIMERR and legacy system. The focus is toward secure and privacy-aware integration of sensor networks with the rest of the system.
- **Task 8.3 – End-to-end ICT System Integration Testing & Refinement (M15-M40):** this task consists of the design and verification of integrated end-to-end BIMERR system. This involves testing, debugging, and verification of compliance with the requirements as well as delivery of easily deployable software bundles.
- **Task 8.4 – BIMERR ICT System Pre-Validation (M23-M30):** this task involves the pre-validation activities in KIRIPIS and CONKAT sites. These act as a testbed for various BIMERR components before the deployment on actual pilot sites.

2.8.2 Description of WP work during the Reporting Period

2.8.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

Table 26 reports relevant deviations with respect to the original WP plan as foreseen in the DoA.

Table 26 WP8's deviations description

Problem Description	Corrective actions undertaken by partners
The work on T8.1 was partially conducted by EXE with no tangible output. This has resulted in the lack of expected interim input for T7.1.	XYLEM took over the lead and work of T8.1. No delay is expected on the task deliverable D8.1 (M32).

2.8.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

T8.1 – External Information Availability & Sourcing: This task started in M4 with a clear plan from EXE to achieve the task objectives. Activities including selection of field experts to refine the component/materials database, as well as identifying existing ICT systems that provide renovation-related component/materials were reported as ongoing as of M9. However, EXE failed to follow the plan and material/components information from field experts were not gathered via surveys as expected during M12-M15. With this delay, it became unlikely that EXE would be able to reach the internal milestone to finalise the database during M16-M19. As EXE left the project, XYLEM took over the leadership of this task. Even though there was no tangible outcome on behalf of EXE, the project is committed to delivering according to the DoA.

In immediate plan for this task is to implement a two-phase collection method. In the first phase, we will send questionnaires to the pre-validation and validation site partners (CERTH, CONKAT, BX, FER) to obtain information on external wall, roof, uppermost ceiling, and floor constructions of the thermal building hull as well as information on windows, doors, heating systems, domestic hot water production, cooling systems, and artificial lighting. In the first phase, the partners will provide us only with information on thickness and material names with regards to constructions, and construction years with regard to the components (windows, doors, etc.). In the second phase, we will request more detailed information dependent on the feedback obtained in the first phase. E.g., COP and energy carrier of heating system.

Based on the collected feedback, we will check if similar or equivalent materials and components are already present in the BIMERR Building Material and Component Database or if we have to extend the database to enable RenoDSS and other BIMERR applications to run the baseline calculations for the pre-validation and validation sites.

T8.2 – Design & configuration of Middleware for Information Exchange throughout Architecture: This task started in M10 with requirements gathering to identify integration points and project challenges of information exchange throughout the architecture. After careful consideration of the technical requirements, the role of a middleware in project became more apparent. Using the middleware to proxy all the communication from applications to the BIMERR interoperability framework (BIF), as conceptualized in the project

proposal, was deemed unnecessary and an architecture anti-pattern. Instead, we decided to focus on secure and privacy-aware information exchange between BIF and the sensor networks of pre-validation and pilot sites. All other applications developed as part of BIMERR shall communicate directly with BIF. The integration of essential legacy ICT systems with BIF remains responsibility of the middleware, however, we are yet to identify such third-party systems.

By M12, there was a concrete plan and a proposed architecture for the middleware. The proposed initial architecture and roadmap were documented in D3.5 as part of the overall BIMERR architecture. In summary, the middleware, as a collection of components, realizes integration requirements in a micro-service architecture. The services may be deployed on edge or cloud infrastructure depending on the use cases. The development of components stated in M13 and four components (i.e. Storage, Registry, Data Processor, Identity Provider) were made available by M17 in a cloud environment to project partners for early testing and feedback.

T8.3 – End-to-end ICT System Integration Testing & Refinement: This task started in M15 with a concrete plan to deliver an initial set of integrated BIMERR software packages by M26. In particular, the identification of components and their interfaces is underway. This has already highlighted the security challenges which will be addressed based on state-of-the-art security practices documented internally in M17. The proposal outlines user and application authorization schemes based on OpenID Connect[12] identity layer in-line with the Building Information Secure Provisioning (BISP) tool to implement access control across all BIMERR applications. Moreover, the T8.3 work on the definition of a testing plan for end-to-end integration of BIMERR components is in progress.

T8.4 – BIMERR ICT System Pre-Validation: Although the work plan defined in the DoA initially called for beginning the pre-validation activities on M23, the consortium decided to push these activities earlier, in order to gather more data within the time available. To that effect, access was provided to all partners that need it to the historical data and to the real-time values of the IoT sensor framework in KRIPIS, while also the design of a BIM model of the building initiated, based on the architectural, electrical and mechanical drawings of the

[12] https://openid.net/connect/

building. Moreover, to assist in the efforts of T5.2, a full laser scan of the building took place along with a photo session to be used for photogrammetry. Finally, regarding CONKAT pre-validation activities, an onsite audit was executed in M18, in which the building dimensions were recorded, and the 3D laser scanning was executed with a GeoSLAM ZEB-REVO laser scanner. The output of this audit was the creation of the 2D floorplan (to support the wireless sensor topology creation), and the point cloud of the laser scanning. The BIM model and detailed photos are going to be used for photogrammetry.

2.8.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Table 27 provides details about the overall work by partners involved in WP8. The table inputs are collected by the WP8 Leader (FIT) incorporating information from the relevant partner's QMRs.

Table 27 WP8's work done by partners during the 1st Reporting Period

Task	Partner	Activities performed in this period
T8.1	EXE	• Identified the objectives of the task and discussed the potential outcomes. • Identified the relevant field experts (via CERTH & CONKAT) to refine the component/materials database. Identified existing ICT systems that provide renovation/construction related components and materials (sourced from T3.4)
	CONKAT	• Identification of the alternatives available for the pre-validation pilot and recording of their characteristics. • Initial identification of the pilot characteristics • The technical characteristics of the pre-validation site equipment were identified and mapped • The preparatory actions for the pre-validation activities (laser scanning, photogrammetry) are ongoing. The technical requirements of the laser scanning are being identified and a research of the available equipment for the activities is running. • Final mapping of the technical characteristics of the pre-validation building • Execution of on-site measurements and creation of floor-plans
	UPM	• Analyse and access external data sources to be integrated in the BIMERR knowledge graph
	CERTH	• Preparation of sensing/monitoring devices/network data sources in Smart Home
	XYLEM	• Request input from validation and pre-validation partners
	BX	• Input about materials and components at the validation site in Poland

T8.2	FIT	• Gathering requirements for components integration • Middleware initial concept design and architecture design • Started the implementation of three components (storage, registry, data processor) • W3C WoT Thing Description data model implementation into registry component • SenML impl. improvements in storage component • Setup of a demo server for middleware • Discussion regarding the sensor measurement query requirements (and where to store data) • Documentation of registry and storage • Realization of Data Processor for pre-processing and ingestion of synthetic data • Working toward data sync features of the storage module for distributed storage • M18 demo preparation • Analysis of suitable and secure identity provider solutions • Deployment, configuration, documentation of Identity Provider (as a new component of the middleware) • Implementation of API access control for registry component • Data Processor interfacing with KRIPIS data sources
	SUITE5	• Contribution to the design of information exchanges between the BIMERR Middleware and the BIMERR Interoperability Framework
	CERTH	• Preparation of sensing/monitoring devices/network data sources in Smart Home to provide access to partners for middleware development and testing
	UBITECH	• Contribution to the design of the BIMERR Middleware and its alignment with the BISP
	HYPERTECH	• Participation in call to discuss sensor query requirements
T8.3	FIT	• Task kickoff with a proposed plan for integration and delivery of BIMERR components • Data storage automated testing • Data storage automated release workflow (docker images, binaries) • Registry automated testing • Registry automated delivery workflow (docker images, debian packages, binaries) • BIMERR Access Control discussions • Documentation of guidelines related to the use of Identity Provider for project use cases • Discussions with partners regarding the access control approach
	SUITE5, XYLEM, HYPERTECH NT	• Participation in access control call
	CERTH	• Pre-pilot site access to facilities and provision of data for integration

		testing • Participation in online meetings systems integration
	UBITECH	• Activities related with the communication of BISP with other resources and the identity manager • Participation in access control calls
	BOC	• Contribution to demo preparation
T8.4	CERTH	• Preparations to provide networking access to KRIPIS sensor data • Initial design of BIM models for KRIPIS • Full laser scanning of the KRIPIS building
	CONKAT	• Execution of laser 3d scanning onsite for the pre-validation building • Processing of laser 3d scanning results and creation of point cloud and BIM files • Execution of photogrammetry on site
	UEDIN	• Meetings to select/agree data acquisitions solutions for the pre-validation sites. • Processing of data from the pre-validation sites in view of July review. • Created photogrammetry guidelines for partners (WP09 as well)

2.8.2.4 WP DELIVERABLES

No WP8 deliverables were due in the first reporting period.

2.8.2.5 WP MILESTONES

No WP8 milestones were due in the first reporting period.

2.8.3 WP Plans for the next Reporting Period

Table 28 summarizes the plans for the next period for each task.

Table 28 WP8 plans for next reporting period

Task	Planned Activities Description
T8.1	• Finalise the materials/components with (BX, FER, CONKAT) to be stored in the database of T7.1 (M22) • Gather requirements from T9.1 and T9.2 for final demonstration sites using BIMERR (M25) • Finalisation of BIMERR component/materials database (M32)
T8.2	• Finalized implementation of storage component with distributed synchronization capabilities, secure API, full documentation • Finalized implementation of registry component with complete and secure API for

	search and discovery, full documentation • Realization of various flows in data processor component to interface with all pre-validation and pilot sites and transform and route data according to the requirements • Implementation of over-the-air software update tool for removing configuration and monitoring of gateway devices
T8.3	• Integration testing of BIMERR components • Packaging and release of components • Continuous integration and delivery workflows • Validation of components in pre-validation and validation sites and further refinements
T8.4	• Execution of main pre-validation activities • Dry-run of components in pre-validation sites for in depth testing • Reporting of problems and challenges • Generation of use manuals for use by renovation experts • Draft of tested use cases and examples

2.8.4 COVID-19 Impact

The scheduled activities for WP8 according to the DoA were not affected by COVID-19 during the first period. Task T8.4 BIMERR ICT System Pre-Validation is planned to start at M23 in the second period, but the consortium decided to start it ahead time to be able to go into the actual pilot activities with a more mature system. The pandemics had an impact on these activities, as described in the next paragraph, but there is no delay in regards to the DoA.

There has been a delay in the execution of the on-site audit at the CONKAT pre-validation building related to T8.3 which was actually to start only at M23. The audit was initially planned to be executed in the beginning of March 2020 with scope to create the as built 2d-floorplan of the building and map the existing equipment and building characteristics. However, due to the health crisis this audit could not be executed when anticipated, in order to ensure the health and safety of the auditor and the building users. As a result, the audit was executed when the health measures were eased, during June 2020 when also the laser scanning and photogrammetry actions took place.

No major risks that could cause delays or deviations from planning are projected for the next period. The plan is to procure the equipment and sensors for pre-validation activities starting from September 2020 (internal procedure already started) and install them this Autumn. If new measures are applied in the next couple of months due to the pandemics, the

installation procedure will be adjusted accordingly but no general lock-down, that could cause major delay in the installation, is projected.

2.9 WP9 - Validation & Evaluation Activities

2.9.1 Summary of the WP objectives

The main objectives of WP9 are:

1. To carefully plan the validation activities in the real renovation sites for smooth usage of the BIMERR tools and ensure availability of the necessary information for the evaluation;
2. To engage and train the renovation stakeholders that will be directly involved in the demonstration activities;
3. To deploy the BIMERR tools to the pilot sites, making both the necessary hardware and software resources available to the renovation stakeholders;
4. To conduct the demonstration activities in parallel with the renovation project planning and implementation; and
5. To evaluate the impact of the BIMERR system based on the quantified outcomes of the renovation activity.

WP9 consists of five tasks which aim to achieve the above-mentioned objectives:

- **T9.1 - Design of Demonstration Activities, Ex-ante Renovation Project Analysis & Evaluation Baseline Establishment (M13-M29)**: This task focuses on planning demonstration activities which includes preparation of two facilities for demonstration of BIMERR tools, preparation of the demonstration activities plan, preparation of a methodology for evaluating the effectiveness of BIMERR tools and their impact on the renovation process.
- **T9.2 - Renovation Stakeholders Engagement & BIMERR Tool Training Seminars (M22-M32)**: The purpose of this task is to convince and engage the stakeholders involved in the modernization process on pilot buildings to use BIMERR tools within their standard tasks and activities during renovation of the building.
- **T9.3 - BIMERR Tool Roll-Out & Deployment for Demonstration & Validation Activities (M28-M32)**: This task aims to create a plan and conducting the actual implementation of the ICT BIMERR system at modernize pilot buildings.

- **T9.4 - Demonstration of BIMERR Tools on Real Renovation Projects (M30-M40)**: The purpose of this task is to perform demonstration and validation activities on selected demonstration objects during the entire renovation process, which will consist of collect all the necessary information required for the assessment of BIMERR tool performance. The plan provides practical use of the digital model creation tools and renovation-support tools.
- **T9.5 - Post-renovation Assessment & Evaluation (M30-M42)**: This task includes the work for the evaluation of the BIMERR tools in action during demonstration activities and their influence on: results of the renovation process, energy savings, user acceptance for renovation process.

2.9.2 Description of WP work during the Reporting Period

2.9.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

During the reporting period, there have been no deviations from the DoA in the work performed in WP9.

2.9.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

The main outcomes of this WP during the first reporting period are the selection and detailed description of the pilot buildings as well as the establishment of dialogue with the building administrators and with the residents living in both pilot buildings in Poland and Spain. During these meetings, the "Consent to Participate" forms were distributed to the residents. A total number of 12 apartments in Poland and 4 in Spain, with additional 3 apartments has been identified. These apartments are now being subjected to the WSN design by project partners. The detailed description of the pilot sites including information about the condition of demonstration buildings has been provided to project partners.

A first external LiDAR scan of the Polish Pilot building has been performed and a 3-D point cloud of the building has been created as shown in Figure 17. Some preliminary scans of the first four apartments in the Polish pilot building have also been performed, and are currently being processed.

Figure 17 3D point cloud of the Polish pilot building

Moreover, till month 18 within task T9.1, effort was directed at development of the evaluation methodology that will target characteristics of the pilot buildings.

2.9.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Table 29 provides details about the overall work by partners involved in WP9. The table inputs are collected by the WP9 leader (BX) incorporating information from the relevant partner's QMRs.

Table 29 WP9 work done by partners during the 1st Reporting Period

Task	Partner	Activities performed in this period
T9.1	UOP	• Organization of T9.1 KO telco • Telco and discussions with BX for the building characteristics • Initial work on baselining
	CONKAT	• Identification of role in the framework of the task and preparatory actions.
	FER	• Developed contacts with housing cooperatives and communities, local authorities and public administration in Spain in order to find the best and most suitable option for the Spanish pilot site to validate BIMERR solution. • Gathered as much as possible technical information about the Spanish pilot

		site. • Defined BIM model requirements. • Final selection of the pilot site. • Prepared administrative documentation such as collaboration framework with the owner of the building. • Gathered input for online questionnaires,
	UEDIN	• Contributed to selection and planning of data acquisitions solutions for Scan-to-BIM at the validation sites.
	BX	• Established a cooperation with the Warsaw City Hall in order to provide a pilot building. • Organization and plan for work in WP9 prepared together with partners • Final selection of the pilot building. • Preparation of all formal matters so that it is possible to conduct demonstration activities on the pilot building • Gathering of input for online questionnaires
	FIT	• Participation in kick-off call • Set up of the cloud infrastructure for secure collection and retrieval of residential profiling and energy consumption data
T9.2		Not started yet
T9.3		Not started yet
T9.4		Not started yet
T9.5		Not started yet

2.9.2.4 WP DELIVERABLES

No WP9 deliverables are due in first reporting period.

2.9.2.5 WP MILESTONES

Table 30 reports the status of Milestones foreseen for the work package during the 1st Reporting Period.

Table 30 WP9 milestones status related to the 1st Reporting Period

Milestone	Lead	Due	Status
MS12 - Selection of buildings	BX	M12	achieved M17

MS12 has been delayed for 5 months because the consortium decided that just selecting the pilot buildings would not be binding enough for the project. For this reason, the means of verification for this milestone was redefined to be the following: i) to have a pilot building description; ii) to have a letter of intent signed by the building owners. As soon as we met these conditions in M17, MS12 was approved. Having followed this procedure, MS4 is automatically approved, although it will be due only in M24.

2.9.3 WP Plans for the next Reporting Period

Table 31 summarizes the plans for the next period for each task.

Table 31 WP9 plans for next reporting period

Task	Planned Activities Description
T9.1	• 3D scanning and creation of the BIM model for pilot building, energy audit of the building, installation of the sensors in selected flats. Presentation to the building administration, of the modelling outputs in demo building depending on the thermo-modernization variant. • Time-Cost-Energy Baselining • Fine tuning the evaluation methodology to target the specific characteristics of the pilot building • Plan and schedule the activities related to the BIMERR demonstration and evaluation
T9.2	• Presentation of the details of the BIMERR tools to the: building administration, renovation contractor, planners, project managers, workers building residents. Training activities at the renovation sites address to the different stakeholder group
T9.3	• Preparation of the equipment and systems that enables application of BIMERR tools prior to the renovation process on pilot buildings • Handing over devices enabling the use of BIMERR tools to all stakeholder involved in the renovation process
T9.4	• Application and demonstration of the BIMERR tools during the thermo-modernization process • Assessment and evaluation of the renovation process supported by all BIMERR tools for energy performance of the demo buildings
T9.5	• Start the necessary work for the validation of the BIMERR tools and the evaluation of pilot sites' results

2.9.4 COVID-19 Impact

Polish pilot site: From the beginning of the pandemic outbreak in Poland until the beginning of July, BX has been working from home in a rotational way. Most of the BX activities required by WP9 were carried out with no deviations. In Mid-July, an on-site meeting with residents from the pilot building was held, taking all the safety measures needed. It is unclear how the situation will evolve in the coming months. For the test sites, part of the equipment will be located in the areas of common access in the building, the other part will be located in people's homes. The most critical activity considering the pandemics is for sure the installation of sensors in the households. Once sensors are in place, there will be almost no need to visit the test site in person for at least one year (on site validation of the BIMERR components start on M30) so the risk should drop to a minimum. Only eventual maintenance activities related to sensors, if needed will remain at high risk.

Spanish pilot site: Since March 2020, because of the pandemics, travelling to Bilbao where the pilot building is located was not possible and for that reason, the collaboration with the public administration and with the residents turned out to be more challenging than expected. It created lack or delay of response from stakeholders like administration, BIM subcontractors, residents, and building administrator. In the upcoming months, the COVID situation will still have a considerable impact, especially regarding the collaboration with residents. Now it is possible to travel between cities in Spain, but entering the flats or meeting with residents is still a challenge. The pilot is a social housing building and for that reason interaction through video conference is limited.

Measures: Some measures have already been taken to assure the proper collection of pilots data during the 2nd reporting period:

- The consortium is creating a plan on how to minimize the need to visit the flats, e.g. whenever possible, similarities among the flats' geometries will be considered. This measure applies for the Spanish as well as for the Polish test sites.
- For the Polish pilot-site, a considerable number of the apartments, identical to those that will be used for monitoring purposes, have been scanned. This means that BX won't need to enter some of the apartments for scanning purposes. Currently, they are being modelled by BX technical team. As for the Spanish pilot site, FER is working on a solution to have the laser scanning of the flats and shared areas to occur as soon as possible to avoid entering a period of more restrictions due to the pandemics.

- Under WP8's risk mitigation, we have brought forward the pre-pilot activities. This has an effect on WP9's pilot activities, since through that measure we'll have a more mature system to be tested at the actual test sites. This implies in a higher likelihood of not having to visit test sites in person. This measure applies for the Polish as well as for the Spanish test sites.
- Based on plan views, the WSN (Wireless Sensor Network) topology design has been provided and measures have been taken to proceed with the procurement and installation the soonest possible. This applies for both test sites.

In a later phase of the project, for the validation of BIMERR tools on site after the pre-validation, visits to the pilot sites cannot be avoided, e.g. use of Hololens ARIBFA app and BICA app to collect data that cannot be obtained by other means.

The risk mitigations and measures due to the impact of COVID-19 listed here are an open list which is going to be followed-up regularly. If need be, it will be modified and extended.

2.10 WP10 - Dissemination, Exploitation & Standardization Activities

2.10.1 Summary of the WP objectives

The main objectives of WP10 are to:

1. To define, update and manage the BIMERR dissemination and communication strategy and plan
2. To implement the project's dissemination and communication activities, as anticipated in the plan.
3. To establish, organize, manage, and support the BIMERR Living Lab throughout the project lifetime as a critical source of stakeholder feedback and contributions, project outcomes transfer and promotion of open innovation
4. To prepare accordingly and promote the BIMERR outcomes to the appropriate standardization bodies and committees
5. To define the BIMERR system Exploitation Plan and its components, as well as the design of the business innovation plan that will pave the way for their commercialization.

WP10 consists of five tasks which aim to achieve the above-mentioned objectives:

- **Task 10.1 – Dissemination and Communication Plan & Activities (M1-M42)**: The goal of this task is to deliver a comprehensive Dissemination and Communication Plan (DCP)

describing the project's strategy, activities, and implementation instruments. Moreover, in the framework of this task, all the anticipated activities in the plan will be implemented and be under a continuous evaluation.

- **Task 10.2 – BIMERR Living Lab Activities (M1-M42)**: The aim of this task is to establish an open innovation 2.0 and value co-creation framework, involving end-users and stakeholders either directly participating in or affected by the project and ranging from the project consortium partners to relevant end-users and stakeholders (AEC professionals like architects, engineers, project manager, contractors, workers, but also home owners, etc.), along with scientific, technological and relevant business communities.
- **Task 10.3 – Analysis & Documentation of Best Practice Examples of Renovation Support Activities using BIMERR Tools (M21-M42)**: The aim of this task is to generate material with which the AEC stakeholders can directly relate to, in an effort not only to disseminate BIMERR outcomes to their natural end-users but also to effectively promote their exploitation by illustrating to the users real-life case studies where the tools have made a sizeable impact in the daily activities on colleagues under representative conditions of pressure for delivery
- **Task 10.4 – Exploitation strategy and preliminary business innovation planning (M6-M42)**: The goal of this task is to define the plan for the exploitation of the project's tangible and intangible results and to create a preliminary business innovation plan for the results.
- **Task 10.5 – Preparation for and Promotion of BIMERR Results to Standardization Bodies (M18-M42)**: Activities of this task aim to promote the BIMERR standardization proposals on construction, data modelling and linked open data to standardization bodies, committees and working groups.

2.10.2 Description of WP work during the Reporting Period

2.10.2.1 DEVIATIONS FROM PLAN DURING THE REPORTING PERIOD

Table 32 reports relevant deviations with respect to the original WP plan as foreseen in the DoA.

Table 32 WP10 deviations description

Problem Description	Corrective actions undertaken by partners

Due to the restrictive measures applied over Europe because of the health crisis, the second round of living lab workshops on pilot sites was not able to be executed, since they require physical presence of the participants.	The second round of living lab workshops will be organized after month 20 of the project, when it is anticipated that the restrictive measures will have been eased. If there are still restrictive measures in place the consortium will switch to online events, for those workshops
The quantified intermediate target for participation in external events, at month 18, was not possible to be reached by the consortium, since all the events organized after the first half of the first quarter of 2020, were cancelled or postponed.	The consortium will now switch to participation in online external events, while double effort will be put when the events with physical presence will start again, in order to meet the final KPI, of the participation in external events category.

2.10.2.2 SUMMARY OF WP WORK DURING THE REPORTING PERIOD

The main outcomes of this WP during the first reporting period are documented in the following deliverables:

- D10.1 - BIMERR branding, website, and social media channels;
- D10.2 - BIMERR dissemination and communication plan, and associated material 1;
- D10.3 - BIMERR dissemination and communication plan and associated material 2;
- D10.6 - BIMERR Living Lab activities evaluation Report.

Moreover, effort was put during this period in the initiation of activities towards the definition of a plan for the exploitation of the project's tangible and intangible results, while the activities under T10.5. Preparation for and Promotion of BIMERR Results to Standardization Bodies, started in M18. In more detail:

T10.1 Dissemination and Communication Plan & Activities: During the first reporting period all the anticipated actions under this work task, have been implemented. As analysed in D10.1 and D10.2, the dissemination and communication plan consist of three discrete phases. In the first period the "design phase" took please, where the dissemination and communication plan was drafted, and all the predicted actions were mapped and organized on a specific timeline. After M6 and the submission of D10.2 the second phase begun, namely the implementation phase. During this phase, all the dissemination and communication actions described in the plan will be implemented, while the plan will be constantly updated, according to the changing project needs, the results of the completed actions and the changes in the external environment. The last phase will be the evaluation

phase, which will run during the last months of the project and will assess the completed dissemination and communication actions.

The design phase of the dissemination and communication actions was completed in M6, and its outcome was the drafted dissemination and communication plan, as described in D10.2. Moreover, during this period the BIMERR project official website (www.bimerr.eu) was delivered, as the starting point for anyone that is seeking to learn more about the project. In addition, the official account of BIMERR in the major social media were created, in order to increase the audience that the project can reach and make BIMERR go viral and be "mentioned" and "re-posted" by a substantial number of followers. Thus, the official accounts of Twitter, LinkedIn, and Facebook has been created, which will be updated weekly, according to the social media posts timeline, in which all partners are triggered to participate by providing one post each week. The branding design had also been finalized. A unique logo was created, where the use of green and blue colour implies the eco-friendly and forward-thinking character of the project, combined with the harmony and simplicity of the BIMERR philosophy. Moreover, the use of violet implies the innovative character of the project. In addition, the graphic identity of the project had been developed. All project templates and PowerPoint presentations were created in consistent with the branding design. The colours used for these templates and presentation of other materials are the ones used in the BIMERR logo. The project brochure had been also finalized providing a detailed and non-technical overview of the project, aiming at a wider target audience. In this brochure, there is a page with a summary of the project and a page on the objectives, the BIMERR methodology, the scope, and the expected impact. Focus was given on the use of pictures to make it attractive to the audience.

During the second phase, namely the implementation phase, the dissemination and communication actions were executed according to the continuous updated dissemination and communication plan. The only deviation had to do with some actions from M15 (March 2020) to M18 (June 2020), that had to be cancelled or postponed because of the health crisis due to the COVID-19 outbreak which resulted to cancellation or postponement of all the organized events that included physical presence of the participants. The project website during this period was updated in a regular basis, with newly inserted parts in the "tools" section from input received from technical partners and in the "pilot sites" section with details about both the pre-validation and validation sites, as provided by the relevant pilot partners. The social media channels of the project were update with news and updates

according to the feedback of partners, but in order to ensure the fulfilment of the relevant KPI, it was decided to create a social media posts timeline, in which each partner will be responsible to create a post for the social media channels each week. Moreover, during this period three newsletters were issued by the project. One in M12 of the project (December 2019), one in M17 (May 2020) and one in M18 (June2020). The first newsletter included general information about the project and presented the project "in a nutshell". Moreover, it provided details about the living lab activities and the latest news of the project. The format and the layout of the newsletter was common with the general project layout and colour picking. The second newsletter of the project included information about the BIMERR pilot sites, both the pre-validation and validation buildings, and an update about the project news while the third will be issued by the end of M18 (June 2020), including information about the BIMERR tools and an update about the project latest project news. Moreover, during this period, the BIMERR partners participated in external events and competed a series of activities, to promote and disseminate the project and its results, while they completed and some publications or submitted papers. All those activities are presented in detail in D10.3.

T10.2 BIMERR Living Lab Activities (M1-M42): The BIMERR Living Lab activities are developed from a very early stage of the project implementation (user requirements phase) up to the pilot evaluation phase in order to engage the target groups in the project. During the design phase, building upon the user-driven approach of Living Labs, the first step was the definition of BIMERR end-users in D3.1.

Following that, for the implementation and the support of the actions included in the Living Lab activities, a dedicated space was designed in M03 and presented in M04 inside the project website. The dedicated space increased the interaction between the Living Lab participants and the consortium and promoted the engagement of the users with the completion of the questionnaires provided in D3.1. Moreover, in the dedicated space for Living Labs on the BIMERR website, the end-users are invited to complete the end-user requirement Questionnaires, offered in 4 different languages according to their user groups.

Overall, one of the main tools for the end-user's engagement is the establishment of a Living Lab database, which includes the personal data of the participants in Living Lab activities. With this tool the BIMERR consortium creates a pool of interested end-users that can formulate the final product during the development of the BIMERR project. End-users and stakeholders stem from the networks of the BIMERR consortium partners. All partners are

responsible to provide contact details and to obtain the consent from end-users and stakeholders that are participating in the project Living Lab activities. The Living Lab database is used as the pool for future dissemination activities and the list will be continuously updated though the development of the project.

Moreover, as part of Living Labs Methodology, targeted Living Lab workshops are organized together with the involvement of the definition of various interaction and collaboration mechanisms to take advantage of the participation of key construction stakeholders. As described in the Grant Agreement and the DoA, Living Lab workshops will be performed (further to other planned engagement and training activities). The aims of the Living Lab workshops are:

- to raise awareness, engagement, and acceptance of renovation stakeholders, also including the preparation and distribution of appropriate material;
- to involve end-users in the requirement definition activities of the project;
- to involve stakeholders in the evaluation of BIMERR results.

The initial planning is to organize several workshops in various countries. The first Living Lab workshop concerned the collection of requirements from stakeholders and was hosted in M05 in Poland (BX), under the support of MERIT as Dissemination and Exploitation Manager. The meetings were attended by representatives of selected organizations, focused on the construction industry, as well as BIM experts and construction supervision employees. Information on the methods, tools and technologies currently used in the process of planning, implementation, as well as research on the effectiveness of thermal modernization of residential buildings are crucial for the success of the project. The aim of the workshops was to determine the expectations and needs of potential users and recipients of innovative tools, which will be the result of BIMERR's design work.

In addition, on the 19th of June 2019, in FER premises in Madrid, and on the 12th of July 2019 in the IVE's offices (Instituto Valenciano de la Edificación), Ferrovial Agroman's Urban rehabilitation Area and its R&D Department organized two different requirements workshops in the framework or the BIMERR project. The aim of the workshops was to lead debates and conversations about the state and need of the renovation industry. In the early stages of the project, it is indeed fundamental to gather concrete and clear information about how things are done nowadays and how the new tool should be developed to meet the requirements

and needs of the end users, so that BIMERR's effectiveness and future impact is as big as possible. Moreover, according to DoA, the training seminars and working groups with standardization bodies will be organized at a later stage of the BIMERR project under Task 9.2.

Finally, according to the initial plan, it was anticipated that the second round of living lab workshops would have taken place during month 18 of the project. Unfortunately, due to the restrictive measures applied over Europe because of the health crisis, the second round of living lab workshops on pilot sites was not able to be executed, since the organization plan required physical presence of the participants. To overcome this barrier, it is now anticipated to organize those workshops after M20, when it is predicted that the restrictive measures will have been eased. If there are still restrictive measures in place the consortium will switch to online events.

T10.4 Exploitation strategy and preliminary business innovation planning (M6-M42): The Exploitation strategy activities are carried out within T10.4 to define the potential exploitation routes for BIMERR integrated solution and the BIMERR components. These are in line with the Innovation Management model defined in section 8 of D2.1 Quality Assurance Plan, and this is the ISAEP innovation framework, that analyses the areas of Identification, Selection, Acquisition (and Development), Exploitation (and Transfer) and Protection. Furthermore, these will be supported by the elements of Business Model Canvas, with the definition of Value proposition and the Customer segments and customer relationships, aiming to define the chapters of a concrete Exploitation Plan for BIMERR solution. The methodology of the exploitation plan was developed at the first months of the project, including four phases, and receiving input from other deliverables and all consortium partners: (1) Identification/ characterisation of Key Exploitable results (M06-M18); (2) Market definition and ecosystem analysis (M06-M18); (3) Exploitation Plan and monetization routes. Business Model (M12-M24); (4) IPR protection Tools and strategy (M18-M24).

The first phase of the Exploitation methodology, that took place the first months of the project development, was focused on the definition and the preliminary analysis of BIMERR tangible and intangible assets. All BIMERR components that will be offered within BIMERR integrated solution and will be also exploited individually by project partners, were initially analysed regarding the value offered, the distinctive advantage and the key characteristics that act as strengths and weaknesses of the project results. A dedicated questionnaire was

circulated to project partners to collect the mentioned information, which will be consolidated at the final Business Model and Value proposition designs during the following months. Finally, 13 components were defined, 12 as intangible assets and one tangible: BIMERR Interoperability Framework, BIMERR Renovation Decision Support System (RenoDSS), Process & Workflow Modelling and Automation toolkit (PWMA), Scan- to-BIM, Augmented Reality enabled In-situ Building Feature Annotation (ARIBFA, Profiling Resident Usage of Building System (PRUBS), Building Information Collection Application (BICA), Renovation material components database, BIMERR ontology network, Building Energy Performance modelling module (BEP), BIM Management Platform, Secure Provisioning Tool (part of BICA) and the BIMERR Middleware.

Another important element of the Exploitation Plan is the definition of the Intellectually Property Rights strategy for the project outcomes that will have the potential for exploitation as a new entity, through licencing agreements, as shared knowledge, information and other possible types. For this purpose, a preliminary mapping of IPR protection tools for all BIMERR elements was defined with monetisation options, as these are shaped at this phase of the project, with license, sub-licensing, business partnerships and joint venture potential being most selected ones.

In parallel to the definition of BIMERR results, the target markets and the potential target customer segments were identified, with a focus to analyse and understand their real needs and expectations. A preliminary market read for AEC (Architecture-Engineering-Construction) industry and Building renovation market took place, evaluating the market growth prospers, the market trends and potential barriers of penetration. Market segmentation methodology and well-known strategic tools were used to build our analysis. Regarding the customer segments, AEC industry remains the main focus market as the highest potential ones and other markets like BEPS software market, building design consultancies and BIM toll developers are of interest and will be evaluated as secondary target segments.

All findings combining the internal and external BIMMER ecosystem insights, including BIMERR results, customer segments value, and market trends will be consolidated in the first version of the Exploitation Plan, in deliverable D10.10 BIMERR Exploitation and Business Innovation plan 1, which is in progress.

T10.5 Preparation for and Promotion of BIMERR Results to Standardization Bodies (M18-M42): This task has just started and the main progress are the draft questionnaires for gathering partners current participation and plans regarding standardization bodies, identification of W3C groups (the Web of Things and the Linked Building Data) in which BIMERR use cases could be shared with and participation in W3C groups meetings (this activity is performed since previous months as some partners are involved in such groups).

2.10.2.3 WP WORK PER PARTNER IN THE REPORTING PERIOD

Table 33 provides details about the overall work by partners involved in WP10. The table inputs are collected by the WP10 leader (MERIT) incorporating information from the relevant partner's QMRs.

Table 33 WP10 work done by partners during the 1st Reporting Period

Task	Partner	Activities performed in this period
T10.1	MERIT	• Development of BIMERR Graphic Identity. Creation of several versions for the BIMERR logo in order the consortium to choose the most suitable. • Creation of several project templates (PowerPoint presentation, Deliverable Document, Meeting Minutes, press release template) and branding of BIMERR. • Creation of Website and Social Media of BIMERR project. • Constant updates of social media channels with posts regarding the consortium activities with contribution from all partners. • Constant update of the project website with new sections and updated news • Production of Communication and Dissemination Materials for the BIMERR project (brochure, roll-up,) • Creation of 3 project newsletters • Constant evaluation of the dissemination and communication actions towards the specified KPIs • Submission of D10.1 - BIMERR branding, website and social media channels

		• Submission of D10.2 - Dissemination, Communication Plan (DCP) and associated materials 1. • Submission of D10.3 - Dissemination, Communication Plan (DCP) and associated materials 2 • Support and organization of various actions for the communication and dissemination of the project outcomes. • Constant identification of future dissemination & communication opportunities and application submissions • MS11, MS7 Achievement
	FIT	• Contribution for the social network post of the week • Contribution in website updates and newsletters • Review of D10.3
	UEDIN	• D10.2: Contributed (review and suggestions) to the dissemination and communication plan. • Led a (unsuccessful) bid to host the International Symposium for Automation and Robotics in Construction (ISARC) in 2021 in Edinburgh. We had suggested to BIMERR consortium (and got support) to use that event to promote BIMERR's outputs to the academic community (e.g. by holding a workshop during the conference). • Submitted (unsuccessful) RICS Magazine piece. Contacted CIBSE Journal as alternative. • Supported BIMERR communications on social media. • Provided Tools description for project website as well as feedback on website presentation. • Led the initial contact to co-funded H2020 projects (as part of the review conducted in T3.3). • Engaged with industry professionals to contribute to the Living Lab survey
	HYPERTECH	• Feedback provision on BIMERR branding. • Feedback provision on BIMERR website and its context. • Contribution to social media post updates • BEP and PRUBS tools description for the project website update • Presentation of the BIMERR activities to the sister projects meeting • Paper submitted - in proceedings of LDAC2020. • An abstract with the title "Towards Increasing the Building Energy Performance Estimation Accuracy: BIM-to-BEPs and Occupant Profiling Methods" has been selected for inclusion in the EEE2020 conference

		(https://energy-evaluation.org/) program as a poster. However, due to the spread of the COVID-19 virus, the conference has been postponed until further notice.
	XYLEM	• D10.6 review • Tools description for the project website update • Contribution to social media post updates
	UBITECH	• Contribution to communication activities on social media and other communication mechanisms
	CONKAT	• Review of deliverables D10.1 and D10.2 • Contribution in the content of newsletter #2 • Contribution in the dissemination of project through available channels • Contribution in the dissemination of project newsletter through available channels • Continuous support in the dissemination of project results • Contribution for website update regarding the pre-validation site description
	NT	• Contacting the Slovak BIM association about the possibilities of the BIMMER project presentation
	CERTH	• Support BIMERR communications on social media and through other channels. • Contribution in the dissemination of project through available channels • Contribution in the dissemination of project newsletter through available channels
	UPM	• Presentation of BIMERRR at COP-25 Madrid at green zone • LDAC2020 organization. Supported by BIMERR http://linkedbuildingdata.net/ldac2020/#support • Sedit workshop organization. Supported by BIMERR https://sedit.linkeddata.es/#supporters • Support BIMERR communications on social media and through other channels. • Ontologies description for website • Linked Data in Architecture and Construction Workshop (LDAC2020) organization • International Workshop On Semantic Digital Twins (SeDiT 2020) organization

		• LDAC2020 paper preparation (accepted) about BIMERR Occupancy Profile Ontology • Contribute to social media posts (post of the week) • Linked Data in Architecture and Construction Workshop (LDAC2020) organization • International Workshop On Semantic Digital Twins (SeDiT 2020) organization
	UOP	• Feedback on BIMERR flyer • Support BIMERR activity on social media • Announcement (in Greek) in the University's periodical newsletter • Support BIMERR dissemination and communication activity
	BOC	• Contribution of BIMERR profile • Contribution to BIMERR branding, website and social media channels using the ADOxx.org community (more than 4300 developers) • Contribution to Dissemination, Communication Plan (DCP) • Several review contributions • BIMERR Development Space on ADOxx.org is online • BIMERR Press Release is published
	SUITE5	• In-house presentation of the BIMERR Project, Suite5's roles and responsibilities, milestones to be achieved and alignment with the corporate strategy, to the company's personnel and shareholders • Provision of comments and feedback towards the improvement of the BIMERR communication material • Preparation of the BIF-related description for the BIMERR website • Contribution to the BIMERR communication activities on social media and other communication mechanisms.
	BX	• Support BIMERR communications on social media and through other channels. • Polish pilot description for website
	FER	• General Press release for BIMERR (English and Spanish) • Articles about two requirement workshops • Support BIMERR communications on social media and through other channels. • Translation for the online questionnaires • Pilot description for website

T10.2	MERIT	• Establishment of the Living Lab Methodology in D10.2 and submission of deliverable • Coordination with UoP in line of T3.1 and fist workshop • Online tool setup for the publishing of questionnaires in 4 languages (English, Spanish, Polish, Greek). • Draft of Consent form for the participants of the Questionnaire. • Upload the final Questionnaires in the dedicated domain on the website. • Coordination with BX, FER, CERTH, CONKAT for the translated inputs. • Creation of a list with participants for the Living Lab Activities in Confluence. This list needs to be completed with at least 5 proposed stakeholders from every partner. • Implementing the specific actions described in the dissemination/communication plan for the Living Lab Activities. • Promotion of Living Lab Methodology and activities - future interactions. • Support in the organization of living lab workshops in Poland and Spain. • Organization of the second round of workshops in the pilot sites which had to be postponed after all and re-organized for month 20, due to the restrictions applied because of the health crisis. • Continuous follow up of living lab questionnaires and close cooperation with T3.1 leader
	CERTH	• Support living lab activities and pilot partners in the organization of living lab workshops.
	UPM	• BIMERR questionnaire dissemination
	HYPERTECH	• Support living lab activities • BIMERR Questionnaire dissemination • Contributed to the Living Lab preparation activities in Poland and Spain
	CONKAT	• Participation in teleconferences for living lab activities • Contribution to living lab activities execution and to the drafting of living labs plan • Contribution in the organization of the first round of living lab questionnaires • Translation of living lab questionnaires in Greek • Creation of users group and distribution of questionnaires in relevant stakeholders
	BX	• Organization of user requirement workshop in Poland

		• Translation of living lab questionnaires • Creation of users group
	FER	• Realization of requirement workshops, which constitute the first steps of the living lab activities, as the workshops participants (construction clusters and associations, public administrations, BIM experts, construction site managers and workers) are going to be involved throughout the project. • Developing and maintaining active the living lab activities and the corresponding network (stakeholders, participants…) • Even though the second round of workshops was postponed, FER maintained contact with stakeholders involved earlier in the project, so that they can be solicitated again later on in the project, when further workshops are needed.
T10.3		• Not Started yet
T10.4	MERIT	• Telephone Conference in order to launch the activities of Task 10.4 • Review and alignment with D3.4 market analysis • Allocation of roles and responsibilities for the T10.4 • A preliminary Business Innovation Plan was provided for D2.1 • Upload in BSCW the initial ToC of D10.10 in M7 for early discussion of allocation of work in this Task. • D10.10 ToC finalization and responsibilities restructuring • Definition of the methodology to analyse Key Exploitable Results including questionnaire to receive important information from partners. • Design of market analysis and key players mapping methodology • Creation of initial market analysis for BIMERR segments. • Preliminary market analysis for renovation/construction market and its key players. • Consolidation of the information provided by project partners regarding the BIMERR results.
	SUITE5	• Preliminary exploitation considerations for the BIF and BICA.
	HYPERTECH	• Input for exploitation questionnaire
	XYLEM	• Input for exploitation questionnaire
	CONKAT	• Participation to the questionnaire Exploitation and preliminary business innovation planning
	BOC	• Input for exploitation questionnaire

		• Development of the BIMERR Innovation Shop for internal and later also external innovation hand-over. • Work on the Innovation item "Process-Oriented Decision Support"
	BX	• Completed BX questionnaire for exploitation results
	NT	• Input for exploitation questionnaire
	FER	• Participation to the questionnaire Exploitation and preliminary business innovation planning
T10.5	UPM	• Design questionnaires drafts to gather information from partners potential results and standardization bodies to contribute to or aligned to. • Analysis of BIMERR use cases to be pushed towards standardization groups. • Participation in W3C Linked Building Data group meetings (before the task started) • Stablishing conversations with W3C Linked Building Data group members about the group future developments and possible links with BIMERR results (before the task started) • Participation in weekly W3C WoT Discovery meetings (since M14)
	FIT	• Presentation of BIMERR device registry use case to W3C Web of Things (WoT) working group • Participation in weekly W3C WoT Discovery meetings (M16-M18) • Contribution to the formulation of the W3C WoT Discovery requirements and design decisions • Demonstration of the BIMERR's directory service in W3C WoT Plugfest (June 2020) • Presentation of latest design challenges in W3C WoT F2F (June 2020)

2.10.2.4 WP DELIVERABLES

Table 34 reports the status of deliverables foreseen for WP10 during the 1st Reporting Period. For each deliverable, title, lead beneficiary, due date and submission date are reported.

Table 34 WP10 deliverables status related to the 1st Reporting Period

Deliverable	Lead	Due	Status

D10.1 – BIMERR branding, website, and social media channels	MERIT	M03	Submitted M03
D10.2 – BIMERR dissemination and communication plan, and associated material 1	MERIT	M06	Submitted M06
D10.3 – BIMERR dissemination and communication plan and associated material 2	MERIT	M18	Submitted M18
D10.6 – BIMERR Living Lab activities evaluation Report	MERIT	M12	Submitted M12

2.10.2.5 WP MILESTONES

Table 35 reports the status of Milestones foreseen for the work package during the 1st Reporting Period. For each milestone, title, lead beneficiary, due date and status (achieved/not achieved) are reported

Table 35 WP10 milestones status related to the 1st Reporting Period

Milestone	Lead	Due	Status
MS11 - Project website launch	MEIRT	M03	Achieved M03
MS07 - Public Awareness, Dissemination and Engagement Planning	MERIT	M06	Achieved M06

2.10.3 WP Plans for the next Reporting Period

Table 36 summarizes the plans for the next period for each task.

Table 36 WP10 plans for next reporting period

Task	Planned Activities Description
T10.1	• Continuous update of BIMERR Dissemination and Communication Plan • Continuous evaluation of Dissemination and Communication Activities performance and evaluation towards the specified KPIs • Newsletter#4 to be released in M22 • Newsletter#5 to be released in M26 • Newsletter#6 to be released in M30 • Continuous update of social media channels according to the social media post timeline plan • Continuous update of the website with news and updates about project results • Continuous update of future proposed dissemination & communication opportunities • Release of second project brochure by M27

	• Release of second project poster by M28 • Release of second project roll-up by M29 • Release of first project leaflet by M30 • Submission of deliverable D10.4 "BIMERR dissemination and communication plan and associated material 3" in M30
T10.2	• Continuous monitoring of living lab activities and opportunities with pilot partners. • Research for relevant living lab activities and opportunities during the technology implementation phase of the project. • Re-organization of the second round of living lab workshops, according to the limitations applied due to health crisis and agree on new dates after M20. • Organization of third round of living lab events in the pilot site areas by M30
T10.3	• Gathering of material from pre-validation testing for best practices • Gathering of material from pilots testing for best practices • Documentation template draft for the use of BIMERR tools and services • Use case studies definition for specific desired outcome types (cost reduction/energy efficiency etc) • Coordination of efforts among all technical partners to provide input regarding the best use of their tools
T10.4	• Deploy the Exploitation boost seminar by EU Exploitation services. • Definition of BIMERR Key exploitable Results, as the highest potential commercialized entities. • Preliminary definition of the Value Proposition for BIMERR Key Exploitable Results Progress • IPR strategy and agreements.
T10.5	• Define final questionaries' to identify potential resources and standardization bodies to contribute to and share with all the partners in the project • Identify standardization bodies in which partners are involved or plan to. • Identify standards being used or planned to be used by partners. • Map BIMERR results and resources to standardization bodies. • Identify action plans to promote BIMERR results in standardizations bodies. • Design mechanisms to keep the information updated through the project lifecycle. • Communicate with BIMERR use cases involved partners about sharing the description of the use cases in standardization bodies and define the terms of sharing. • Complete analysis of BIMERR use cases and outcomes to be transferred to standardization groups

2.10.4 COVID-19 Impact

With regards to the dissemination activities of WP10, some actions from M15 (March 2020) to M18 (June 2020), had to be cancelled or postponed because of the health crisis due to the COVID-19 outbreak. More in detail all the external events (workshop, forums, conferences, thematic events) that included the physical presence of the participants, were cancelled or postponed and as a result, the consortium participated only in online events during this period. For the next period it is anticipated that the consortium will participate in online events and put double effort in event participation, when the restrictive measures are eased, in order to reach the relevant KPIs.

Moreover, the second round of living lab workshops were to take place during M18. Since it required physical presence of the participants, we had to cancel it. To overcome this barrier, those workshops are planned to take place after M20. If there are still restrictive measures in place, the consortium will switch to online events.

2.11 IMPACT

2.11.1 Progress on Measures to achieve expected impact

The main advancement in this period towards the achievement of the impacts set for the project is the development of the BIMERR evaluation methodology within T3.3 and its documentation in D3.3. The evaluation methodology creates a robust framework which defines the KPIs to assess the performance of renovation projects under the utilization of BIMERR tools. The use of BIMERR tools in real renovation works in the context of the use cases proposed in D3.1 was considered along with the four major impact KPIs described in the DoA, i.e. reduction of renovation process duration, reduction of the renovation process cost, improvement of user acceptance and increase in energy efficiency. A thorough detailed description of the evaluation methodology is documented in D3.3. It is worth noting that the methodology considers KPI that match all impact points: renovation process duration, renovation process cost, user acceptance, energy efficiency, occupants comfort and air quality, sustainability, and economic issues.

Regarding the work towards a wide uptake of BIMERR solutions, the first period outcomes are: i) a set of initial versions of all BIMERR tools which can now be used as early demonstrators; ii) prepone activities in the pre-pilot sites which allows for an early start of

data collection and tools' validation as well as for the operation of a more mature system in the two pilot sites; iii) Living lab workshops conducted in Poland and Spain and engaging representatives of 7 main user groups (architect, BIM modeller, building surveyor, project manager, site manager, worker, occupant). Details about these activities are reported in 1.4.1.1 and 2.10.2.2, task T10.2; iv) foreground work on the generation of best-practice examples to directly relate to AEC stakeholders.

Regarding the best-practice examples to be generated based on the project demonstration activities and its relation with standardization working groups, the work in the first period gives the basis for task T10.3 (*Analysis & Documentation of Best Practice Examples of Renovation Support Activities using BIMERR Tools*) through the initial version of the BIMERR tools and the analysis of regulations and markets in D3.4. This sets the ground for the work in task T10.5 (*Preparation for a Promotion of BIMERR Results to Standardization Bodies*) which started in M18.

The progress reported in item 2. of this section represents the foreground work done within the first period to achieve the social, economic and environmental impacts set for the project. A wide uptake application of the BIMERR solutions will lead to significant annual energy savings, emissions reduction, real state value increase of the EU building stock. Based on these results, BIMERR will also contribute to tackling the energy poverty problem in the EU and to create jobs.

The foundation for the adoption and establishment of a user-driven innovation environment was set within the first period through living lab workshops with stakeholders as reported under 1.4.1.1 and 2.10.2.2 as well as through the work on stakeholder requirements for the BIMERR system within task T3.1/D3.1.

Apart from step that have been taken to develop and deliver the BIMERR toolchain, further steps have been identified to increase the user acceptance. Since BIMERR introduces numerous tools, each with its own UI, the consortium realized the value of a consistent appearance and initiated a UI's coordination working group. Another significant measure towards achieving the expected impact on time considers the steps that have been taken during the 1st reporting period to expedite the pre-validation activities, starting with the data collection process earlier than initially planned. For both pre-validation sites the 3D-scanning was performed and draft BIM models in Revit have been created. However, the data quality

checking of the exported IFC files remains open. Based on the CONKAT building's plan views the WSN topology design was sketched and the procurement of the IoT devices has been scheduled, while the KRIPIS building, already equipped with an IoT solution, has provided access to historical IoT data.

2.11.2 Progress on Measures to maximize impact

All dissemination and exploitation activities ran on the first period are reported in detail in section 2.10.2. Here, a list in a nutshell:

- The overall dissemination and communication strategy has been worked out in D10.2 and is continuously updated considering the impact of the already executed actions, as described in D10.3;
- The major dissemination and communication activities have been executed according to plan: BIMERR website creation and the follow-up of its statistics, BIMERR social media accounts, 2 scientific publications, 8 major external events;
- The dissemination and exploitation target groups have been defined and classified, the specific activities for each target group have been defined;
- The analysis of renovation tools market and prevailing regulatory frameworks has been included in D3.4. This is going to be completed with the preliminary market analysis to identify BIMERR market trends and characteristics and customers in buildings renovation sector, BIM sector and AEC as well as with the analysis of the internal and external BIMERR environment with SWOT/ PEST analysis to be included in D10.10, M24;
- The BIMERR tangible and non-tangible exploitable results and their key characteristics have been identified and listed in section *2.2.2.2.1.7 BIMERR Exploitable Assets*;
- The first round of the living lab workshops has been completed, with workshops that took place in Poland and Spain as described in D10.6. The second round of the living lab workshops is organized to be executed in the next months;
- The analysis of BIMERR use cases to be pushed towards standardization groups has started and consortium members participated in "W3C Linked Building Data" group meetings about the group future developments and possible links with BIMERR results.

In addition to all dissemination and exploitation activities which occurred in the first period, extra effort has been done to maximize impact:

- The BIMERR use case has been added to the W3C Web of Things (WoT) working group to be incorporated as part of WoT Architecture Smart Building use case. The Middleware Registry (LinkSmart Thing Directory), developed for BIMERR WSN metadata management has attracted community attention and is considered as a reference implementation for WoT plugfests and the formulation of WoT Discovery standard specification;

- The BIMERR activities related to W3C Web of Things were advertised in a newsletter available through the BIMERR website;
- BOC follows an Open Community approach and offers its innovation items resulting from BIMERR in the open ADOxx.org community that consists of more than 4.300 ADOxx developers. The so-called innovation shop that lists all results with the corresponding explanation and documentation is made public in form of a first version with the innovation items (a) Process and KPI Design, (b) Simulation, (c) Process Mining, (d) Process Model Wiki:

  https://adoxx.org/live/web/bimerr/downloads;jsessionid=830EA623CDB95770BAC6CD477DEEEA8E

- A cooperation with the national FFG project CALIBRAITE has been established, where the renovation processes from BIMERR are used to study how ethical relevance of KPIs are expressed and visualised. KPIs that are calculated, simulated or assessed will be presented in different ways, indicating the level of trust. The results from CALIBRAITE are also used for the second iteration of the BIMERR prototype;
- An upcoming H2020 project with successful evaluation is likely to start in November 2020 and will consider BIMERR's partial results. Synergies will be worked out so that BIMERR will benefit from the developments. Internal hand-over is ensured by involving members of the BOC management board in BIMERR.
- UPM co-organized the Linked Data in Architecture and Construction workshop where one of the BIMERR ontologies has been presented and accepted as peer-reviewed paper. The overall project goal and scope was highlighted during the paper presentation and got the attention of sibling projects' participants and other stakeholders. The workshop had around 120 online participants and average of around 85 per session;
- CERTH has organized a BIM-related workshop where BIMERR will be showcased in October;
- The consortium has committed to participate in a sister projects' workshop during the Sustainable Places 2020 digital event (www.sustainableplaces.eu), to boost the cooperation with other projects in the domain of energy-efficient buildings and building information modelling. We have met the organizers and are working together to shape the workshop;
- In the context of the BIMERR tool RenoDSS, which is being developed by the BIMERR industrial partner Xylem, there is a high interest of the company in collaborating with the monitor of the project Mr. Dobos to get his support regarding concepts for streamlining the system for potential future commercialization activities;
- The BIMERR industrial partner FER participated in many actions to reach out to the residents of the neighborhood called Otxarkoaga in which the pilot site building is located. This neighborhood has its own social media channels and website and it is very active on YouTube, Facebook, and Twitter. Furthermore, Otxarkoaga has its own web radio (https://otxarkoaga.es/). FER Construction is making various efforts to create a link with this neighborhood and communicate about the BIMERR project and its objectives. A way of achieving it is to make publications on Otxarkoaga's social media channels. As a

first result of the efforts undertaken, recently on June 29th, 2020, FER participated in an interview for the web radio programm to present the BIMERR projects and its objectives;

- FER has written an article to be published in its website resuming all activities undertaken with Otxarkoaga;
- The UCL research group participating in BIMERR is co-leading activities in a new Annex organised by the International Energy Agency (Annex 81) on Data-Driven Smart Buildings. The Annex went into the operational phase in June, and the work will be carried over the next three years. The work of the Annex focuses on Building Information Management processes and developing supporting software specification and infrastructure in support of these processes. UCL's developments in BIMERR will also form part of the technical contribution to Annex. This should provide significant leverage at communicating the project results and related developments, at a European and more broadly at international level. The work also will link BIMERR (and the project results) to Mission Innovation Challenge #7 (on Sustainable Heating and Cooling) activities.

3. UPDATE OF THE PLAN FOR EXPLOITATION AND DISSEMINATION OF RESULTS

The initial dissemination plan was analysed in detail in deliverable D10.2, submitted in M6. This plan is aligned with the one described in the DoA, keeping the same targets, the same principles, and the same timeline. This initial plan is foreseen to be through a constant update procedure, during the whole life cycle of the project. This procedure constantly re-evaluates the plan according to the results of the completed actions assessment, without changing the main scope and principles of the initial plan. This constant update procedure results are presented in deliverable 10.3, submitted in month 18, in parallel with this report. Further updates of the plan, if needed, will be described in deliverable 10.4 which will be submitted in month 30. Regarding the exploitation plan, the initial plan is under development and will be described thoroughly in deliverable 10.10 which is due to month 24. Also, in this case, no changes in the principles and scope of the plan presented in the DoA, are expected. Finally, according to the plan the final exploitation plan will be submitted by the end of the project.

4. UPDATE OF THE DATA MANAGEMENT PLAN (IF APPLICABLE)

The data management plan as described in the DoA still holds. Further details on data management are provided in the deliverable **D2.1 extension – Data Management Plan**.

5. FOLLOW-UP OF RECOMMENDATIONS AND COMMENTS FROM PREVIOUS REVIEWS

Comment #1: *"Scope. The scope of the project is very ambitions what was also noted during the submission evaluation process by multiple reviewers previously. Thus, the PM might want to consider whether it is beneficiary for the consortium to reduce the scope in certain areas while respecting the overall budget in order to deliver a coherent solution suitable for market deployment rather than potentially many disconnected research results. One opportunity for scope reduction arises from the funding difficulties of a start-up member GlassUp that were meant to design and deliver a new Augmented Reality (AR) hardware. However, there might be other opportunities to reduce the scope elsewhere, too, that the consortium might want to put forward for the PO to consider."*

We agree that the scope of the project is wide and, if GlassUp does not continue with the project, we agree that we will not try to develop an own hardware smart glass. This was already part of our plan in case of a GlassUp exit. Furthermore, the consortium agrees to carefully evaluate the architecture and implementation of each feature to eliminate feature creep and the undesired expansion of scope that would result. We have identified this as a high impact/medium likeliness risk (#20 in the risk register) and will be monitoring it closely.

Comment #2: *"Digital Twins. Over the past year the digital BIM market has experienced a shift from traditional BIM into Digital Twin solutions, e.g. here: https://www.atkinsglobal.com/en-GB/angles/all-angles/digital-twin-maturity-spectrum and https://www.cips.org/en-GB/supply-management/news/2019/july/westminister-restoration-plans-to-use-digital-twins/ The application of Internet of Things (IoT) sensors and digital facilities management especially for existing stock restoration is only going to grow over the coming years. Thus, as part of the scope re-evaluation the consortium should integrate solutions to address this emerging market, too."*

We agree that recent publications (e.g. Gemini principles or the Atkins/EIT report "Digital twins for the built environment") have brought forward the concept Digital Twins (DT) and that we should develop our discourse to embed it within this wider concept and development of the project. It should also be mentioned that this is a fast-evolving area, with oftentimes conflicting definitions of what constitutes a DT. There is already significant work happening in Europe (e.g. definition of the National Building Twin in the UK by the Centre for Digital Built Britain and related work elsewhere) which is acknowledged. The consortium in closely monitoring these so that the BIMERR solutions can appeal to that emerging market.

In relation to the BIM maturity levels, we highlight the following about BIMERR:

- As the project and DoA are currently shaped, the BIMERR project will provide some components in line with the delivery of a Digital Twin at Maturity Element 3+ on the Digital Twin Spectrum. The components (e.g. Sensor-based occupant behaviour to drive RenoDSS; ARIBFA; and PWMA) are principally delivered in WP6 that addresses the digital twin for renovation processes by using workflow logs, extracted knowledge provided by the renovation process modelling environment as well as integration – using the BIF – of legacy systems. The other BIMERR components and processes, however, are predominantly BIM-based, i.e. Digital Twin Maturity Element 2 on the Digital Twin Spectrum.
- If we do include more activities towards DT Maturity Element 3+, an increased scope will occur, which contradicts our efforts for the previous recommendation.

A significant part of retrofitting decision support concerns the parametric exploration of potential retrofitting solutions, to identify interventions that meet design, performance and cost criteria. This is addressed by "digital twinning" similar to the type highlighted in the second link above (Westminster), where simulation models (possibly physics-based) are introduced and used to effectively explore the space of design alternatives. BIMERR does investigate such tools, with new developments focusing at uncertainty reduction (e.g. by more accurately representing occupants, through the occupancy modelling tasks). In that sense, the knowledge acquired and the tools being developed will contribute to the debate of "digital twinning" for retrofitting (an area which is often overlooked, compared to other phases of a building's lifecycle like e.g. operation). Therefore, acknowledging the role of digital twinning in the foreseeable future, we will seek to highlight where BIMERR developments contribute to the development of digital twins. This is particularly relevant, in the dissemination and exploitation-related deliverables of the project. In particular, we will evaluate how to introduce and integrate digital twinning holistically in the BIMERR context and solutions.

Comment #3: *"Regulations. D3.4 Market Analysis provides a solid understanding of the current BIM regulations. There should be a plan to periodically revisit this summary analysis since throughout the long project duration such regulation in respective countries could change."*

BIM regulations do change rapidly. A periodic revisiting of BIM regulations will be done, generally and if we elicit new requirements and undertake the architecture, implementation, and validation of the project. Any update will be formally reported in M36.

We note that any such changes are continuously towards more BIM (and Digital Twin), with the use of open formats. Therefore, these changes will unlikely impact BIMERR negatively (very low risk to the project); they are in fact only going to further strengthen interest in the project outcomes.

Comment #4: *"Baseline Improvements Comparison. One of the main requirements of the funding is to establish cost and time savings in terms of renovation, many of which pose very high targets to achieve. Therefore, to provide a baseline and an improved result that is measurable and as accurate as possible, it would be desirable to compare refurbishment of individual flats in the same development, some of which would be delivered using the existing techniques while others using the novel BIMERR workflow and toolsets. The ideal situation would be to compare two similarly sized flats within the same development with similar energy requirements, occupancy, etc. in order to have the most plausible baseline for true improvements in terms of energy, time and cost improvements as required. Although it might be potentially difficult in real-life scenarios, it would nevertheless be a worthwhile target to aim for."*

A comparison of similar flats/apartments that undergo the same renovation activities at the same time following as-usual practices against applying the BIMERR workflow and toolsets is acknowledged as a sensible approach to quantify the improvements in terms of energy, time and cost. To this direction, the validation-sites (Polish and Spanish buildings) have been carefully selected to facilitate such a comparison: each validation-site can be viewed as a vertical expansion of a floor footprint (apartments' geometry and thermal characteristics per floor are identical), while a building audit questionnaire has been prepared to extract information for each apartment and identify apartments of similar use. However, it is worth mentioning that in real-life scenarios a renovation task does not often run to different floors in parallel and uncertain parameters (e.g. extreme weather conditions or reluctance of occupants to participate in BIMERR activities) may affect the way the aforementioned comparison is being performed, concluding to misleading results. Although BIMERR consortium is targeting to apply the "similar flats/apartments" comparison approach, all the risks that it might entail have been taken into account to conclude to the BIMERR evaluation methodology, as documented in D3.3.

Comment #5: *"Test Sites. The test site identified in Warsaw is a good example of renovation of existing stock which is over 40 years old and in need of energy efficiency improvements as well as general*

renovation. However, the test sites identified in Spain are of lesser quality for the project due to more recent construction (in one case 2016). Given that Ferrovial is a global construction company, they will be expected to provide better and more varied examples of renovation in the next phases of the project."

In the case of Spain, the pilot site suggested in the proposal phase could not be used for reasons out of our control. We had to invest a lot of effort in finding alternatives, since many of the buildings were indeed built quite recently. Nevertheless, after a longer process more difficult than expected (with many different public administrations), we finally managed to come to an agreement with Bilbao Social Housing Comitee. The selected building is a large building (15 floors) erected in the year of 1961 and in quite poor condition. In conclusion, Ferrovial managed to find and select a pilot site of great quality for the project.

Comment #6:*"General Reporting. Many of the deliverable reports provide breakdown summaries such as "Firstly, Section 1 lists X; Secondly, Section 2 lists Y, etc." This is unnecessary and should be avoided since all the required information in already present in the table of contents. Such summary paragraphs serve no purpose other than padding."*

We fully agree to remove superfluous texts from the reports and deliverables.

Comment #7: *"Proprietary File Formats Support. Deliverable D3.2 Survey of data models provides a very detailed summary of various existing file formats and packages, many of which are open source such as Industry Foundation Classes (IFC) and BIM Collaboration Format (BCF). Nevertheless, the construction and renovation industries still heavily rely on proprietary file formats such as Autodesk Revit (RVT), Civils 3D, etc. Thus, in the following technical development the consortium should also explore the possibilities of integrating with these formats using libraries such as the Open Design Alliance (ODA) https://www.opendesign.com/"*

We acknowledge the discrepancy between open file formats and proprietary formats that are nevertheless widely used in the industry. We also fully agree that from an exploitation point of view, proprietary file formats are important to support as they represent a huge part of the market. Unfortunately, the proprietary formats either do not provide internal details of the implementation, or they require licensing costs that are not justifiable by the project. This makes it difficult to support them. In addition, the promotion of the BIMERR data models and ontological representations to standardization bodies, committees, and working groups consists a core BIMERR activity. In order to assist the future versions of the most relevant standards, the standardization proposals and punch-list preparation entail the adoption of

open file formats (e.g IFC and any other open file formats that have been used within BIMERR).

Comment #8: *"Dedicated Comms Handbook. Deliverable D10.2 Dissemination and Communication Plan provides a good level of detail for relevant communication activities and requirements. However, the consortium partners might find a dedicated Communications Handbook a useful tool to refer to when delivering external dissemination activities."*

We fully agree that there should be a guidance for the partners, regarding the participation in dissemination activities, but we proposed a midway solution to be introduced to lower the administrative and preparation costs of a dedicated handbook. Namely: many dissemination and communication actions and procedures are described in D10.2 and D10.3. Instead of having a Dedicated Handbook that simply repeats these deliverables, we have advertised the deliverables internally as a reference source and encouraged the partners to consider them a living guide – not as "done and finished" deliverables. Moreover, in deliverable 10.3, submitted in month 18, a dedicated paragraph named "Partners roles – Procedures" was introduced, with scope to provide concise directions about participation in dissemination activities, while this part will also be uploaded in the confluence common space. This part will be a live concise guidance, that will be constantly updated during the project and updated in each version of "dissemination and communication plan and activities report"

Comment #9: *"Data Models vs Ontologies. The consortium partners need to come to a common understanding of discrepancies and similarities between data models and ontologies."*

This issue has been solved in the final version of the architecture in which it is established that the ontologies and data models will be complementary and linked components. More precisely, the data exchange between BIMERR applications would be defined and modeled as the ontology level, providing an open ontology network that could be reused by third-parties. Such ontologies are converted to the more flexible BIMERR data model optimized for BIF features. The ontology-to-model converter is provided within the Building Semantic Modelling tools and generates the JSON serialization of an ontology to be shared with the Model Lifecycle Manager and to align the ontology and BIMERR data model keeping track of changes.

Comment #10: *"Unified Informed Consent. The consortium has taken the decision that all matters of GDPR and data privacy are Page 2 of 9 to be handled by respective partners who have established*

processes already in place since they will be individually responsible for collection of data, anonymisation and final reporting back to the consortium. A list of required points for informed consent collection has been duly listed in D1.1 Ethics Requirements. However, the consortium and the PM in particular should consider providing a standard template form for informed consent collection which can then be adapted and translated by respective project partners. This should ensure better consistency across the project."

A unified consent form has been developed for the project, each partner's (BX and FER) lawyer has approved it. A consent form was signed by the user of the pre-validation site of Conkat in Athens.

CERTH has a standardized informed consent form and GDPR and data privacy compliance document approved by the legal department of CERTH. This was circulated among the personnel in the KRIPIS smart home building that is part of the pre-validation phase of the BIMERR project. The researchers working in the building have read, signed and returned their informed consent forms.

Comment #11: "*Gender Equality. The consortium should monitor gender equality in terms of survey participants as well as project consortium members.* "

We have increased our efforts to monitor Gender Equality and to report the results of the monitoring by creating a Wiki page with number of female and male people working for the project. We will pay special attention to gender equality in respect to survey participants.

Comment #12: "*Workshop Statistics. In D3.1 Stakeholder Requirements, the first workshop in Poland organised by BX in May 2019 has been described in detail, however, crucial statistics and the actual survey results have been omitted as only a derived summary of learning points and case studies have been listed. Based on the photographic evidence it seems that only five participants were present. This is not sufficient as a minimum of 33 participants is required to establish any kind of relevant statistical significance in a scientific undertaking. Thus, for the future, the reports should list the relevant statistics from such workshops as well as include sample (anonymised) answers from the participants, even if only as an appendix."*

We will provide detailed statistics for the workshops and participants. With regard to the workshops that were carried out, we would like to clarify as follows:

The standard approach in user centered design is that qualitative research is done first to identify a list of problems and needs from the stakeholders, without regard to how important each problem or need is and what percentage of stakeholders it affects. For this kind of

research, 5-7 users is the "sweet spot" of knowledge gained versus cost of gaining that knowledge (i.e. cost of workshop, organisation overhead etc. (e.g. https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/). The verification and prioritization of the elicited needs is done later, in a second step, using quantitative analysis and involving more participants. The number of participants for quantitative methods is often about 30, but there exist well-known usability-engineering methods that allow statistical significance already with 10 participants for each user group, e.g. the SUMI questionnaire.

The results reported on in D3.1 were qualitative user research, not quantitative, therefore 5-7 participants is a sufficient number. Nevertheless, this issue was indeed recognized as early as in the kick off meeting, where it was decided to provide an update of D3.1 in M15, in order to have the required time to organise more workshops with user groups as well as get more feedback from online questionnaires distributed to multiple stakeholders. Until the date of submission of the D3.1 update (delayed by 3 months - M18 - due to the world health crisis) it is expected to have 4 workshops organised in the 2 pilot countries with a total of 45 participants as well as feedback from online questionnaires from more than 100 participants.

Comment #13: *"Bottom up TAM. Apart from top-down market analysis, there is also the need to estimate the total addressable market (TAM) also bottom up. The submitted D3.4 Market Analysis deliverable provides the necessary underlying research in terms of potential renovation properties in Spain and Poland for instance so this should be expanded on to provide a realistic market understanding for future commercial exploitation. Most of the work has already been done in terms of estimating the number of renovation projects, etc. However, this should be expanded by estimating potential cost savings delivered by BIMERR in those situations and the likely return on investment (ROI) given a baseline cost figure. Such an analysis would be also required by institutional investors to obtain venture funding should that be required."*

This is something that has to do with the overall BIMERR evaluation (WP9) in the context of baselining for the BIMERR impact indicators (renovation time/cost/energy efficiency) that will be carried out in WP9 in cooperation with WP6 (cost/time), WP5 (measured data), after fine tuning the evaluation methodology provided in D3.3 in order to target sepcific characteristics of the chosen pilot buildings in Spain and Poland.

Comment #14: *"Dissemination Activities. Deliverable D10.2 Dissemination and Communication Plan provides a comprehensive list of upcoming events. However, the current list provides only a generic*

information about each individual event. Instead, the deliverable should list also the proposed activities at those relevant events. For instance, Digital Construction Week in London would be a perfect opportunity in order to exhibit the partial results of the project either at a dedicated stand or as part of the BIM Village."

In the last version of "dissemination and communication plan and activities report" in deliverable 10.3 which is submitted in month 18, we have included in the respective table of the proposed future dissemination activities, a column presenting the proposed activities in each event, as suggested.

Comment #15: *"Scan to BIM. Scan to BIM is still an open-ended research problem and the subsequent parts of the data processing pipeline depend on the quality of the input models. Thus, the consortium should consider back-up scenarios such as manual 3D modelling in case the Scan to BIM solutions are not able to deliver the desired level of quality."*

We fully agree. In fact, the BIMERR project had planned that BIM models of the pre-validation and validation sites be generated manually from the survey data so that the rest of the BIMERR pipeline can be tested and validated irrespective of the performance of the Scan-to-BIM solution.

6. DEVIATIONS FROM ANNEX 1 (DOA)

6.1 TASKS

There are no task deviations to be reported in this period; the project is being executed according to the DoA which has two amendments as described in section 2.2.2.2.2.

6.2 USE OF RESOURCES

General remark on use of resources

The planned effort is estimated by taking into account actual start date/end date of each task comprising that WP but, for the sake of simplicity, by assuming that the overall effort allocated to a partner is uniformly consumed throughout the whole task duration (i.e. no ramp-up / ramp-up phases in activities execution are considered). Given this approximation, misalignments between actual effort and planned effort are difficult to be avoided.

The table below shows the actual effort consumed by each partner in the different WPs during the 1st Reporting Period. It should be noted that the figures reported represent best estimates while the official financial statements, including definitive data, are the ones uploaded using the EC Participant Portal.

Table 37 Actual effort by each partner per WP in the first Reporting Period

Actual Person-Months (M1-M18)																				
WPs	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15		16	17	
	FIT	CERTH	UPM	UBITECH	SUITE5	HYPERTECH	MERIT	XYLEM	GU	CONKAT	BOC	BX	FER	UOP	EXE	HWU	UEDIN	NT	UCL	
WP1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
WP2	12,87	0,61	0,84	0,22	0,64	0,65	0,04	1,16	0,0	0,26	0,11	0,38	0,45	0,3	0,77	0,49	1,72	0,47	0,0	22,0
WP3	5,7	7,67	6,86	4,63	3,62	4,42	6,42	3,31	3,0	6,97	3,85	5,18	3,63	11,79	4,6	2,16	1,9	2,38	0,0	88,0
WP4	3,17	3,63	17,18	8,76	9,55	1,47	1,99	2,04	0,0	3,03	0,0	2,0	1,0	0,72	0,56	0,04	0,83	1,24	0,0	57,0
WP5	1,64	11,6	1,49	0,0	0,72	0,95	0,0	0,0	0,0	2,9	0,0	0,69	0,0	0,67	0,07	0,0	16,87	0,61	0,21	38,0
WP6	0,59	1,08	0,57	0,52	0,74	0,0	0,0	0,0	0,0	3,08	20,63	1,01	1,36	0,0	0,0	0,0	0,0	8,93	0,0	39,0
WP7	0,88	2,49	0,34	0,0	0,0	1,17	0,0	13,45	0,0	5,82	0,0	1,52	0,9	0,0	0,01	0,0	0,0	0,0	0,0	27,0

WP8	3,26	0,72	0,0	0,83	0,89	0,0	0,0	0,01	0,0	1,08	0,28	0,0	0,0	0,0	0,03	0,0	1,06	0,22	0,0	8,0
WP9	3,11	0,0	0,0	0,0	0,0	0,0	0,0	0,01	0,0	0,99	0,0	1,43	1,9	1,63	0,02	0,0	0,16	0,21	0,0	9,0
WP10	1,31	0,16	1,93	0,4	0,38	0,68	8,25	0,5	0,0	1,39	0,98	2,21	1,87	0,45	3,1	0,0	0,5	0,26	0,0	24,0
Total	32,53	27,96	29,21	15,36	16,54	9,34	16,7	20,48	3,0	25,5	25,85	14,4	11,11	15,5	9,16	2,69	23,0	14,3	0,21	**313,0**

6.2.1 Efforts by WP

The histogram below presents the effort consumed in each WP during the 1st Reporting Period compared with the planned effort for the same period.

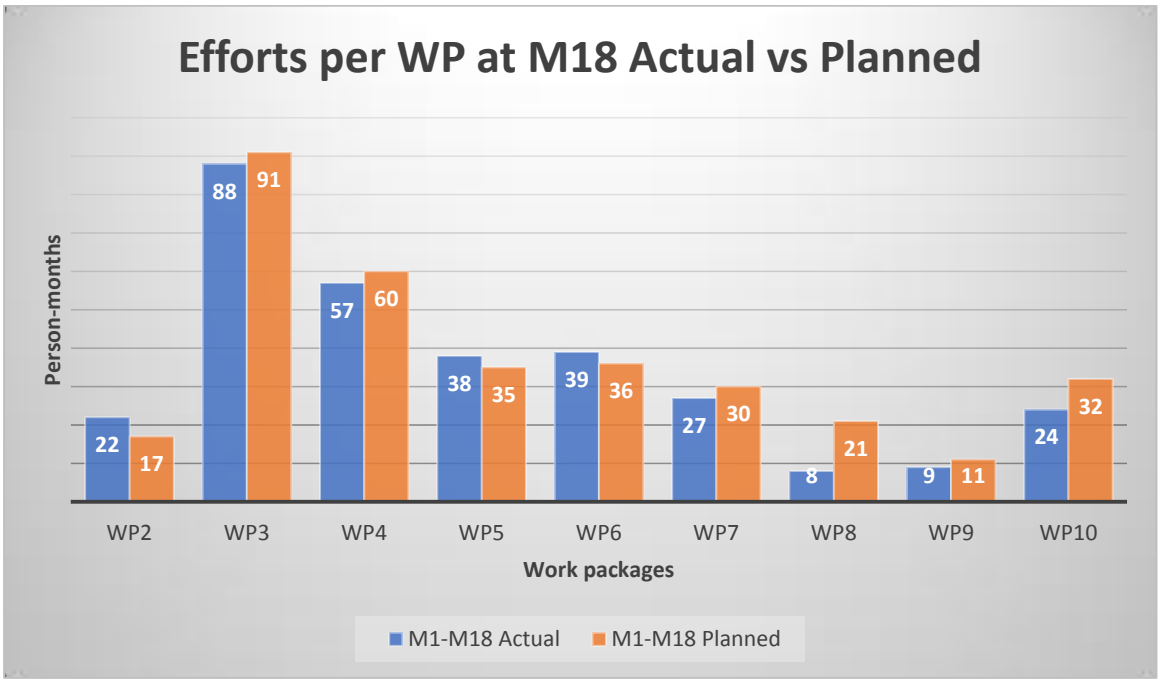


Figure 18 Efforts per WP during the 1st Reporting Period: actual vs planned

For WP8, 9, and WP10, the misalignment due to the linear planning reported during the first review was too high, so the calculation of the efforts' estimation was refined after the review on July 8th, i.e. planning at task level has been done to estimate the effort consumption. This resulted in a low discrepancy for WP9 (only T9.1 was active in the period, having it run for 6 months, the effort consumption should be approximately 35% of the whole task effort) and for WP10 (only 3 of 5 task active in this period). For WP8, there is still a reasonable discrepancy which can be explained by the fact that T8.1 was not fully active under Exergy's leadership and that T8.2 does not involve the work of all partners from the beginning, i.e. the second period will be much heavier on work that the first was for T8.2. Looking ahead, Xylem took the leadership of T8.1 and is fully committed to deliver the work in the second period. The majority of the work within WP8 is going to be carried out in the second period, so the

effort consumption is certainly going to increase and the discrepancy observed in the first period will be corrected. Details on the planned activities for WP8 are presented in section 2.8.3.The next quarterly reports are going to be followed even more tightly than usual by the coordinator.

The histogram below presents the effort consumed in each WP during the 1st Reporting Period compared with the total effort available per WP for the whole project. The overall project has a total of 862 PMs from which 318 PMs or 37% have already been consumed.

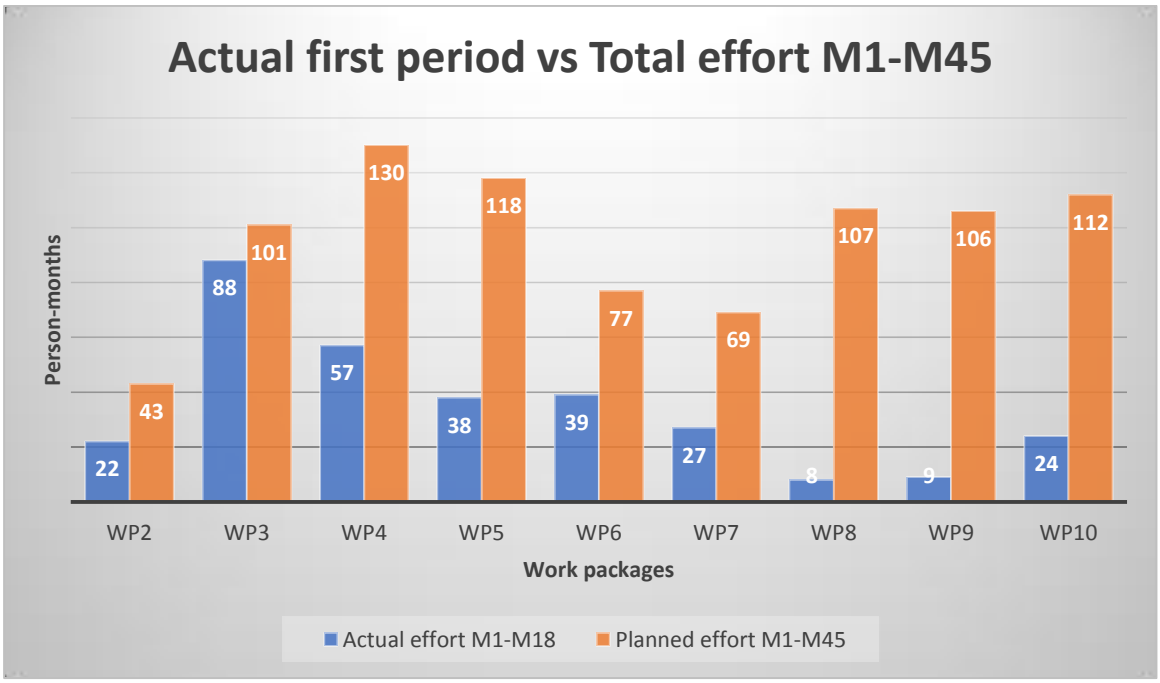


Figure 19 Effort per WP: 1st Reporting Period vs. whole project

6.2.2 Efforts by Partners

The histogram in Figure 20 presents the effort in person-months consumed by each partner during the 1st Reporting Period compared with the total effort available per partner whereas Figure 21 shows the same information in percentage.

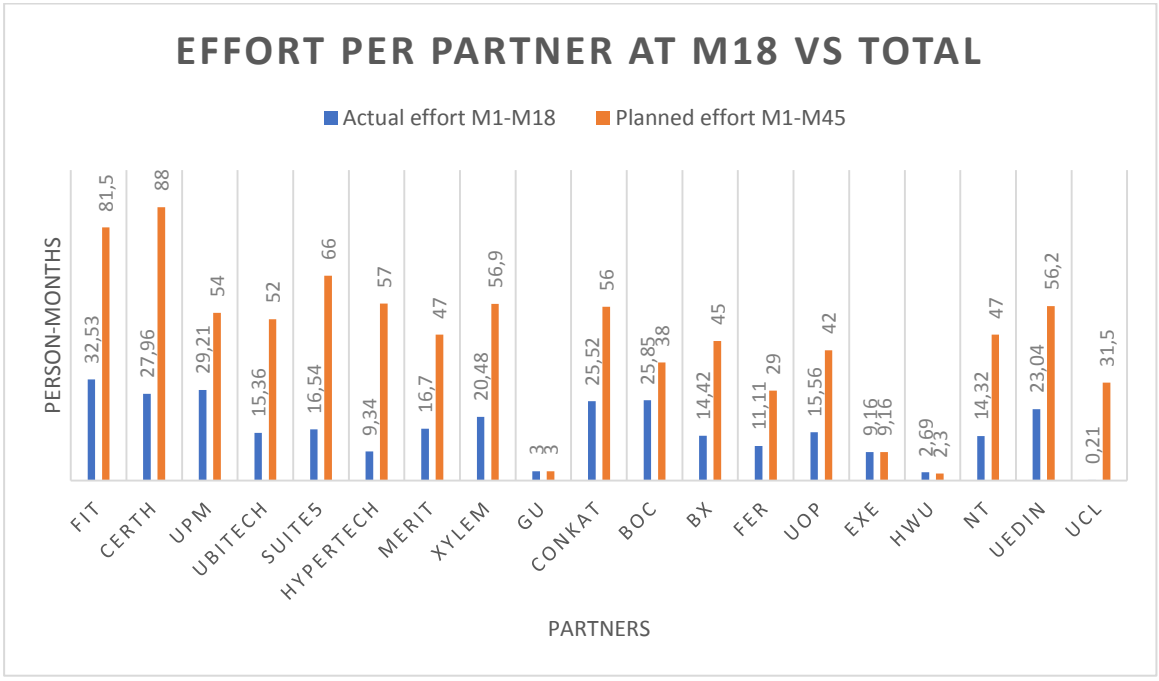


Figure 20 Actual effort per partner: 1st Reporting Period vs Total

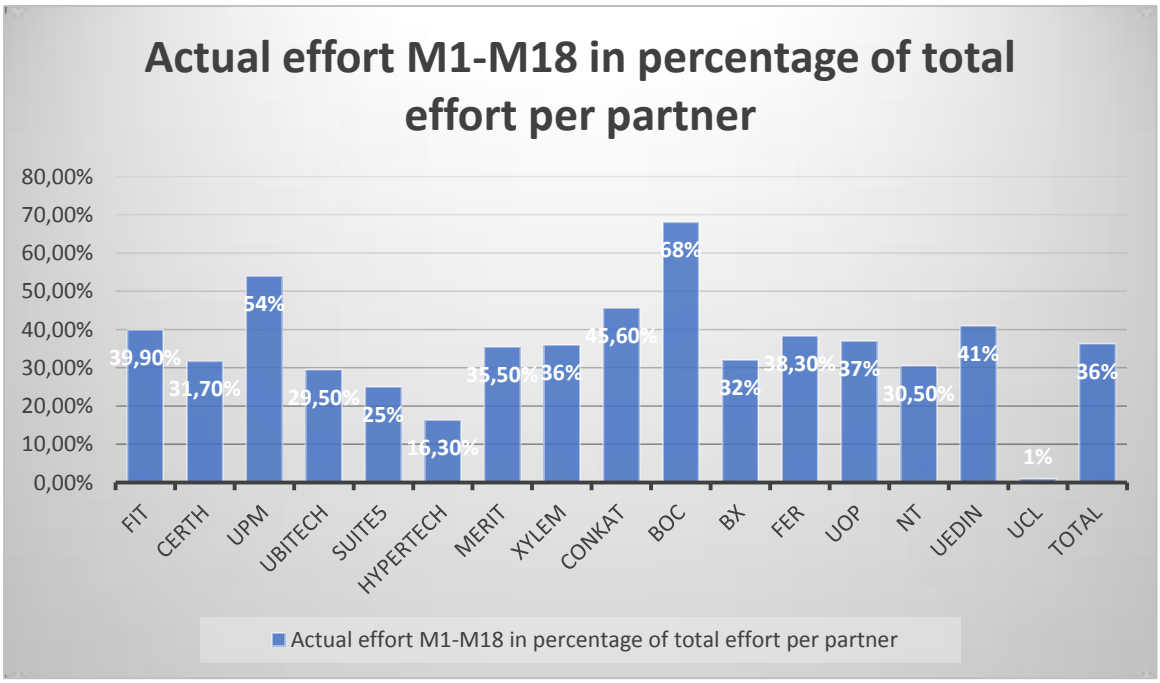


Figure 21 Actual effort per partner: 1st Reporting Period vs Total in percentage

Effort underspending as well as overspending can be observed. In the following, the justification per partner is provided.

CERTH

The justification for under-utilization of PMs in this period can be attributed to three factors. First, due to Exergy's non-participation in WP5 within the period, the effort on the development of the BIM Management Platform dependent activities was put on hold until a solution could be found. In that light, after UCL's introduction to the consortium, efforts have already begun to ramp up for the upcoming period. Secondly, due to GlassUp's non-participation in project activities and the subsequent shift of PMs from T5.5 to T5.6 officially ratified by the 2nd project amendment in December/2019, meant that efforts in T5.5 could not be realized until the amendment was in place. Starting from January/2020 and pending final outcome of GlassUp's financial situation the PM's shifted over to CERTH will be utilized in full in the second period of the project. Finally, due to COVID-19, personnel recruitment in 2020 has been problematic and therefore we are only now beginning to cover the needs presented with the extra effort assigned to CERTH after Exergy and GlassUp exited the consortium particularly with regard to WP5 and with limited availability of high-experienced personnel. With that in mind, we have proceeded to hire more lower PM-rate personnel instead and thus we expect to exceed the planned PMs stated in the DoA but with the same financial cost.

UPM

When the effort was budgeted, tasks were expected to be done mostly by experienced researchers, but after the project has started, less experienced researchers have been more involved, under senior researchers´ supervision. Therefore, the effort spent has increased (however the budget spent hasn't increased since hours of less experienced researchers are also less expensive).

HYPERTECH

HYPERTECH's effort required during the first reporting period of BIMERR was less than expected, due to the erroneous assumption that effort should be linearly distributed in time. This does not correspond to the implementation, integration, and deployment roadmap. Integration activities and data exchange testing/validation will take place during the second reporting period, where the originally planned effort is underestimated.

In more detail, within WP5, the PRUBS tool is built upon an existing user profiling engine (THOR), which embeds and trains comfort models using information streams from sensor networks or other devices about the indoor environmental conditions. Hence, while comfort models for testing have been available from the early stages of the project.

During the first reporting period, HYPERTECH focused on the adoption of existing standards-based data schemas (obXML) as potential data models to capture relevant information.

During the second reporting period, Hypertech will develop and deliver functionalities for seamless communication and data exchange with the BIMERR Interoperability Framework

(BIF), mechanisms to report errors when required information is missing, and a concrete PRUBS module that mainly receives an IoT streams data model, populates the PRUBS output data model (obXML) and send it to the BIF. Furthermore, based on the PRUBS module performance on the pre-validation pilot sites and the capability of the occupant behavior models to capture the occupants' habits, the PRUBS module will be further extended and refined to finally deliver its second version on M30.

With respect to WP7, where HYPERTECH is leading the Building Energy Performance (BEP) module development, the implementation roadmap for RenoDSS modules consists of three main phases. Phase 1 pertains to what has been delivered during the first reporting period, whose scope was to early detect major potential drawbacks that may affect the RenoDSS performance in the pre-validation and validation phases. Phases 2 and 3, referring to what will be issued during the second reporting period, highlight the intensive workload that is envisioned for that period. In Phase 2, based on lessons learnt from phase 1, additional functionalities that deal with supplementary data transfer requirements for candidate renovation scenarios evaluation will be developed towards delivering the core of the RenoDSS, well-integrated with the BIF for proper data exchange and ready to be used for the pre-validation activities on M24. Verification and validation experiments of RenoDSS performed in the pre-validation pilot sites will pave the way to further extensions and refinements of the modules to finally deliver the second version of the integrated RenoDSS modules for deployment and use at the real renovation pilot sites. In terms of the BEP module, since numerous candidate renovation scenarios evaluation requests are going to be sent in parallel, the use of asynchronous communication tools and highly scalable cluster computing techniques to distribute computations and to gather results are going to be investigated and implemented during phases 2 and 3. These will be new features of the toolset to be designed and developed from scratch, so they will require significant effort.

Overall, the effort of Hypertech is sufficient to cover all the aforementioned activities. Its distribution in time however should end-heavy, most effort-intensive activities will happen in the second reporting period.

MERIT

MERIT's planned contributions in the anticipated work of BIMERR were based on our early discussions with the consortium on the basis of the relevant work plan (beginning of 2018) and necessary expertise of the persons involved during the proposal preparation and writing. At that time, MERIT had no employees since it was established in December of 2016 and it was in the start-up phase. According to those discussions and estimated effort and personnel costs, there was an estimation of 5.000 average cost for direct personnel involved in BIMERR project. Afterwards and especially in 2019, MERIT, due to new projects undertaken, decided to hire on a permanent basis more specialised persons and according to their costs, the rate of MERIT's personnel raised.

In more detail the biggest percentage of the total effort allocation of MERIT for the 1st reporting period is in WP3 "Stakeholders Requirements, Evaluation Planning and

Architecture Design" and WP10 "Dissemination, Exploitation & Standardization Activities". In this context during the first period, in WP10, the work plan had to be drafted for the dissemination and the living lab activities, while the drafting of the exploitation plan had to be initiated. Such activities require more senior personnel, since during the first phases of the project the dissemination, communication, exploitation and living lab strategy, activities and implementation instruments had to be defined, and then be implemented during the next phases of the project. Thus, the usual strategy followed, is that more senior personnel participate during the planning and organization of the activities, and more mid-level personnel usually participate in the implementation of those activities, under the guidance of the seniors.

In addition, the same applies also for WP3. Activities under this work package are co-related with WP10 since from one hand the elicitation of end user requirements of work package 3 ran under the umbrella of living lab activities, and from the other hand the survey of existing models and the analysis of regulations and markets are connected with exploitation activities. As a result, the same senior level personnel of WP10, participated in the work execution of WP3.

Therefore, the overall monthly rate raised, and this is mainly the reason of the total deviation occurred during the 1st reporting period.

Xylem

As specified in the amendment, Xylem is carrying out additional work because of Exergy's project exit. As this additional work is carried out by a large extent by the SME owners (with the SME owners cost rate of 36,42 Euros per hour) and because more qualified junior staff is working next to the senior staff in general on the project, the average personnel cost rate is lower than planned.

CONKAT

During the proposal preparation phase of BIMERR, we had anticipated a balance of engineers and researchers to work in the project and carry out our role. Despite those initial estimations, we had to rearrange the balance of our personnel, since we had to implement many different major projects in parallel. This happened because some other major projects, that was predicted to take longer in licensing and preparation procedure, were able to be included in "fast-track" nationwide procedures. As a result, during the first reporting period more mid-level, and less senior personnel, than what was predicted, participated in the project. This caused a minor deviation in the average personnel rate, which is slightly lower than what had been predicted. For the next period, as the preparatory actions are finished and the major pre-validation activities are going to take place, more senior personnel will participate in the project and the average rate is predicted to be closer to the one described in the DoA.

BOC

WP3 - BOC has an overspending comparing planned 2PM to 3.85 PM in month 18 and expect a total overspending of 1.5 PM by the end of the WP resulting in 4.5 instead of 3. This was mainly caused by higher effort in starting phase of the project as well as the provision of some of the contribution earlier as originally thought. This minor overspending has no effect on the budget.

WP6 - BOC has an overspending in WP6 from planned 12 PM compared to 19,3 PM in month 18. This was caused by (a) involving more junior staff than originally planned, (b) the necessity to change the project team after one year and (c) higher effort than expected to provide the first prototype. BOC will carefully reconsider to resize in the ambition of the provided prototype with the help of the stakeholder feedback, efficiently continue with the current project team and expects less effort for the prototype improvement than for the initial generation. Although an overspending in resources is expected, the available budget is considered as sufficient and BOC fully commits to fulfil its obligations.

In total BOC has a slight overspending based on WP6 overspending but has a contingency plan for the second iteration, considers the budget as sufficient for the work and commits to its obligation.

BX

Our deviation in the "personnel cost rate per month" is mainly due to the lower personnel cost rate used in our company. Moreover, recently we also had some changes in our team, which result in the abovementioned deviation.

FERROVIAL

WP3 - In the framework of this work package, we had to invest some extra efforts in translations of online questionnaires. Furthermore, there was a need to re-work the first requirement deliverable and this led to some extension in the task period initially foreseen. As the input from participants was not sufficient, we had to repeatedly attempt to contact stakeholders (AEC professionals and residents) which required higher effort than expected.

WP4 - Our activities were overestimated in the proposal phase as our input was mainly to review the work done by the partners. The PMs that were not spent in this work package are being used in other work packages.

WP6 - As end-users, our input was very important in tasks 6.1, 6.2 and 6.5. We dedicated several efforts in order to draw a map of all the processes that can be modelized from a

renovation project, which was not foreseen in proposal phase (T6.2). This explains the increased number of PM needed if compared to the PMs planned.

WP9 - It is in WP9 that there is the biggest discrepancy with the PMs planned. This is mainly due to the fact that the selection of the pilot site was more complicated and more time-consuming than expected. In proposal phase, an example of building was given, but the timeframe of the project is so long that it was necessary to proceed to a new search and selection of building, and all these efforts in the first year of the project were no taken into account in the PMs distribution.

Because of numerous political changes in Madrid's municipality in the year of 2019, the initial pilot selected in proposal phase was not available anymore. That is the main reason why we had to invert a lot of efforts in finding alternatives with many different public administrations in Spain. Ferrovial had to seek for the most reliable solution in Spain. Finally, a more suitable building was identified in the Basque country. The selected building is a high building (15 floors) erected in the year of 1961 (in quite poor condition), so Ferrovial managed to find and select a pilot site of great quality for the project.

NT

The project team has been created from the actually available staff. After the project proposal has been submitted, we hired new colleagues to cover the work on the project. Their hourly rate is lower than expected. They are capable to provide the same quality under the supervision of the Novitech owner - Dr.Attila Tóth, but naturally, it takes them much work effort.

UEDIN

As for the personnel cost rate per month difference, this is mainly due to the conservative exchange rate used by the University when budgeting in Euros at proposal stage, which is intended to shield from extreme currency fluctuations and subsequent exchange losses. Also, salaries at the beginning of the project are at their lowest, so they will be below the average.

BOC

WP3 - BOC has an overspending comparing planned 2PM to 3.85 PM in month 18 and expect a total overspending of 1.5 PM by the end of the WP resulting in 4.5 instead of 3. This was mainly caused by higher effort in starting phase of the project as well as the provision of some of the contribution earlier as originally thought. This minor overspending has no effect on the budget.

WP6 - BOC has an overspending in WP6 from planned 12 PM compared to 19,3 PM in month 18. This was caused by (a) involving more junior staff than originally planned, (b) the necessity to change the project team after one year and (c) higher effort than expected to

provide the first prototype. BOC will carefully reconsider to resize in the ambition of the provided prototype with the help of the stakeholder feedback, efficiently continue with the current project team and expects less effort for the prototype improvement than for the initial generation. Although an overspending in resources is expected, the available budget is considered as sufficient and BOC fully commits to fulfil its obligations.

In total BOC has a slight overspending based on WP6 overspending but has a contingency plan for the second iteration, considers the budget as sufficient for the work and commits to its obligation.

UCL

Given that UCL joined only recently, there have been no major financial risks thus far. A more volatile market situation, and perceived FX risks have necessitated a lower EURGBP conversion rate for financial projections – this is set centrally by UCL Research Services.

6.2.3 Unforeseen subcontracting (if applicable)

N/A

6.2.4 Unforeseen use of in-kind contributions from a 3rd party against payment or free of charge (if applicable)

N/A

7. APPENDICES

7.1 APPENDIX A – LIST OF BIMERR ONLINE AND PHYSICAL MEETINGS

The following table summarizes all the meetings and on-line conference calls held during the first 18 months of the BIMERR project. Note that meetings held internally by individual partners are not in the table.

Table 38 BIMERR meetings and online conference calls held during the 1st Reporting Period

WP	Meeting Title	Date and Location	Chair and Participants	Main Outcome
WP2 + all	Kick-off meeting	2019-01 FIT, Sankt Augustin	Chair: Markus Eisenhauer Other participants: All partners represented	- Kick-off of the project activities
All	BIMERR Plenary Meeting	April 10th-11th CERTH, Thessaloniki	Chair: Erion Elmasllari Other participants: All partners represented	- Detailed status of activities - Planning for next quartal
WP4	BIMERR WP4 Technical Meeting	May 29th Suite5, Limassol	Chair: Fenareti Lampathaki Other participants: UPM (Freddy, Raúl), Hypertech (Evangelos), BOC(Michael), Ubitech (Danai, Bouras), UOP (George)	- Kick-off of the WP4 activities -Discussion on the interrelations with WP3 and WP6 -Discussion on the current state-of-play in terms of existing tools that the consortium partners bring in WP4 -Brainstorming on key challenges in WP4
All	BIMERR Plenary Meeting	Sep 11th-12th Novitech,Kosice	Chair: Erion Elmasllari Other participants: All partners represented	- Detailed status of activities - Planning for next quartal - Project assessment by project monitor
All	BIMERR Plenary Meeting	Dec 2nd-4th Ubitech, Athens	Chair: Erion Elmasllari	- Detailed status of activities

			Other participants: All partners represented	- Planning for next quartal
All	BIMERR Plenary Meeting	Apr 28th-29th Online	Chair: Markus Eisenhauer, Otilia Kytölä Other participants: All partners represented	- Detailed status of activities - Planning for next quartal
All	Stand-up calls	Bi-weekly, Mondays at 11.30am	Chair: coordinator and technical manager Other participants: All partners represented	- Short status update per work package based on precedent 2 weeks - Reveal blocking issues, if any
WP3	T3.1 online meetings	1/2/2019 8/2/2019 20/2/2019 28/2/2019 18/3/2019 13/5/2019	T3.1 partners	T3.1 progress meetings and technical discussions
	T3.3 online meetings	6/3/2019 26/3/2019 27/3/2019	T3.3. partners	T3.3 work progress and technical discussions
WP4	Weekly or bi-weekly online meetings	Online (19 meetings between Sep 6th, 2019 and June 23rd, 2020)	Participants: All WP4 partners (with the exception of the telco on 06/09/2019 that was intended only for the WP4 task leaders)	WP4 activities progress follow-up, technical discussions and coordination of activities across the different WP4 tasks
WP5	Bi-Weekly or Weekly periodic Online meetings	4/9/2019: GlassUp Situation 6/5/2020 13/5/2020 27/5/2020 4/6/2020 10/6/2020 17/6/2020	Organizer: CERTH Participants: All WP5 partners	WP5 Progress reporting, technical discussion and coordination
WP6	T6.1 telcos	05/07/2019 01/10/2019	Organizer: BOC Participants: All WP6 partners	-D6.1 and T6.1 kick-off -Responsibilities

				and status
WP7	T7.1 Kick-off telco	21.06.2019 (online)	T7.1 participants	T7.1 work plan
WP7	T7.3 Kick-off telco	03.09.2019 (online)	T7.3 participants	T7.3 work plan
WP7	T7.4 Kick-off telco	03.09.2019 (online)	T7.4 participants	T7.4 work plan
WP7	T7.2 Kick-off telco	06.09.2019 (online)	T7.2 participants	T7.2 work plan
WP7	T7.5 Kick-off telco	06.09.2019 (online)	T7.5 participants	T7.5 work plan
WP7	RenoDSS	3.10.2019 (online)	T7.5 participants	RenoDSS sequence diagrams
WP7	RenoDSS	6.12.2019 (online)	T7.5 participants	RenoDSS GUI
WP7	RenoDSS	10.12.2019 (online)	T7.5 participants	BIMERR renovation measures
WP7	BIMERR database	17.12.2019 (online)	T7.1 participants	T7.1 material database
WP7	WP7 planning	28.02.2020 (online)	Xylem and Hypertech	WP7 work plan update
WP7	Validation scenario	14.04.2020 (online)	Xylem, BX and Hypertech	Validation scenario planning
WP8	Pre-validation site sensor network status	2020-01-29	Organizer: FIT Participants: CERTH, CONKAT, SUITE5, UOP	-Handover of technical issues regarding existing sensor network setup of KRIPIS site -Draft of sensor network setup for CONCAT site -Agreement to start parts of T8.4 activities earlier than the DoA to have networking access and 3D scanning data of pre-validation sites as required by other tasks
WP8	Central access control	2020-05-12	Organizer: FIT Participants: UBITECH, SUITE5, HYPERTECH, XYLEM, CERTH	-Mapping identity provider with BIMERR requirements -Agreement on

				role of BISP as central decision-making point for access control -FIT as responsible partner for Identity Provider component
WP8	KRIPIS Network Access	2020-05-29	Organizer: CERTH Participants: FIT	Access to KRIPIS site using the RESTful HTTP API, access details will be communicated by email
WP8	Identity Provider user management	2020-06-12	Organizer: FIT Participants: UBITECH	Overview of various authentication flows and technical requirements for each application
WP8	Version control, software licensing, software delivery	2020-06-24	Organizer: FIT Participants: CERTH, SUITE5, UCL, NT, UEDIN, XYLEM, HYPERTECH, UBITECH	Collection of info about partner's packaging and distribution strategy, documentation, source code management, issue tracking, licensing, public/private repos.
WP9	WP9 kick-off meeting	2020.01.23	Organizer: BX Participants: Xylem, Hypertech, UEDIN, CONKAT, FIT, UOP: UBITECH, FER	-Updated regarding the pilot sites -Preliminary plan for BIMERR tools demonstration
WP9	BIM Requirements	2020.02.18	Organizer: BX Participants: CERTH, FER, Hypertech	-Define 3D laser scanning and BIM model requirements -Guidelines for BIM modelling
WP10	Bimerr living lab	3/4/2019 at 13.00	Merit, BX, FER,	-Living lab

	activities online talk	CET	Xylem, Conkat	activities status -Dedicated space on project website -First workshops in cooperation with task 3.1