
WP2 – ICT Platform Requirements and KPIs Definitions

# D2.3 SPHERE user scenarios and specific requirements for renovation

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## DISCLAIMER



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| Project | |
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| **Coordinator** | IDP – Eduard Loscos / Mikel Borràs |
| **Website** | http://sphere-project.eu/ |
| **Deliverable** | |
| **Deliverable No.** | 2.3 |
| **Deliverable title** | SPHERE user scenarios and specific requirements for renovation |
| **Description** | This task will identify the specification of the use cases and relevant digital twin service requirements based on the previous tasks' findings. The task will carry out the role of bridging the renovation market needs, drivers and the digital twin functionality definition as an enabler to serve the demand.<br><br>***Subtask 2.3.1 Development of the SPHERE Use Cases (EKO)****:* The detailed use cases will be identified based on Integrated Design and Delivery Services (IDDS) framework findings. Unified Modelling Language (UML) methodologies will be used in the task for a normalised specification of needs. Additional technical definitions with sequence diagrams will be identified. Relevant workflows of the user types and the identification of best interaction and communication methods with them will be identified. Needs for monitoring and reporting services including the virtual tools and mobile communication needs via mobile apps, augmented reality presentations and novel visualisation functionalities will be identified. |

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| | ***Subtask 2.3.2 Detailed SPHERE Platform Requirements Definition (EKO)**:* Identification of the complete platform needs for the platform will be made (ICT tools, Digital Twin, IoT, IDDs, building methods, value chain performance procurement, data retrieving, social acceptance). The detailed functionalities of the identified user scenarios and the use cases will be made. The task will also focus on the interoperability of the various services of the platform, with a core focus on the user experience (UX) design. The enhancing user satisfaction with the SPHERE platform will provide the usability, accessibility, and efficiency in the user interaction among the various components of the SPHERE platform, acting as a united single service environment. UX mock ups for the user scenarios will be generated and tested among relevant stakeholders to deliver a satisfactory environment.<br><br>***Subtask 2.3.3 Delivery of the Agile Software Requirement Management Tool (EKO):*** This sub task will deliver the agile development methodology and the quality assurance framework for the substantially software service oriented SPHERE project. The methodology for the component development, integration and quality assurance (QA) will be identified. A cloud based project requirement management and result delivery tool (e.g. Atlassian Jira etc.) will be delivered. The requirements will be uploaded and managed throughout the project lifecycle via the platform. The Quality Assurance methodology and relevant actors of the project with their respective responsibilities will be identified. Identification of the development progress monitoring and agile performance KPIs will be made. The software QA will serve throughout the project as the validation tool for ensuring a close to market and efficient digital twin solution service.<br>The deliverables of this task include the Report on the SPHERE Use cases definitions and software requirement specifications and the requirement and development management tool, hosting the whole set of the requirements and the tools for quality assurance. |
| **WP No.** | WP 2 |
| **Related tasks** | Inputs from T2.1, T2.2<br>Outputs to T3.1, T3.2, T3.4, T3.5, WP3, WP4, T6.1 |
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# 1. Executive Summary

The SPHERE's projects overarching goal is to advance digital tools to build new and improve existing buildings' across their entire life-cycle. Better energy design improved and reduced construction cost, better operational performance, and ease of management, and better overall energy performance fit with a low carbon future. The novelty of SPHERE project is the demonstration and validation of one of the world's first Building Digital Twin platform's with cross-cutting tools for architects, engineers, construction managers, and building facility managers, naming a few, working with both real new building and retrofitting construction cases.

SPHERE as a special innovation project assembles and integrates different information streams needed to make these improvements happen, and bring together close to 20 existing software technologies, advancing them from laboratory or small pilots to large scale demonstrations, on the way for real use by companies. Another socio-technical innovation that SPHERE tries to accomplish is to bring as many actors in the life cycle of a building together through the Digital Twin approach, so they increase collaboration and create co-benefits. For example, for building facility managers to bring relevant operational energy use insights to building designers for making buildings use less energy. Done by advancing the idea of a fully systematic, collaborative and integrated framework for setting up and managing a building construction or renovation projects called Integrated Design and Delivery Services (IDDS).

The purpose of this report is to help SPHERE software tool and platform developers in the project to better understand the needs of potential users of the platform, by defining how the work can be improved of people working in the Architecture Engineering Construction Owner & Operation sector (AECOO). The report also creates a coherent overview of the different software components to be delivered within SPHERE, what these components are supposed to do for different professions in AECOO in terms of outputs, information flows, and features, and how all the software's to be brought together within the SPHERE Digital Twin platform fit together. The work also helps the demonstration works on real buildings to be carried out in Austria, Italy, Finland and the Netherlands in the project, by creating the start of a roadmap for what benefits the demonstration companies in the project can expect in their active design, construction and facility management from the SPHERE platform.

The works in this report will be carried forward to establish the technical architecture of the SPHERE platform. It will help to make key decisions, including what needs to be improved within the existing software tools to be advanced to fit with the AECOO user requirements, what additional functionalities will need to be developed in the architecture for the SPHERE platform to fit with the demonstration companies needs. It also helps by providing the groundwork for defining the data architecture of the platform, by having compiled a large number of needed information flows, and by starting to define specific features that components in the platform will need to have. And finally, it provides the basis for implementing an IDDS guideline sub-module, that will guide the implementation of IDDS as a collaborative practice across the building life cycle. As such, the report provides a compass for future development, in the form of a critical overview of the integrated capabilities of the platform for further development

The deliverable is targeted primarily to the SPHERE consortium of 19 partners in moving forward with delivering the SPHERE platform and its functionalities and features. It is also helpful for companies and other projects consortium who are on their way to deliver similar or complementary platforms for the Architecture Engineering Construction Owner & Operation sector (AECOO), so as to learn and compare new ideas about delivery integrated Digital Twin platforms for buildings.

# 2. Introduction

## 2.1 Purpose and Target Group

The works carried out in this report serve to define at an intermediate level what the services are that the SPHERE platform and related tools should provide, and what features these services should have for particular user types in the life cycle of a renovation or new-build project. Resulting in an Identification of the complete platform needs for the platform. The works serves 9 different purposes based on the project Description of the Action (DoA) related to sections in this report (also see Figure 1 below):

1. Description of specific modules and sub-modules in the SPHERE platform that are to be grouped in **Chapter 4** that provide for specific functionalities, including their linkage to particular tools (briefly described in section 3.2 and with details in Appendix A).
2. Description for specific sub-modules that provide for monitoring and reporting services in **Chapter 4** under the platform, including identification of the format provided (such as the virtual tools, mobile apps, augmented reality presentations and novel visualisation).
3. Specification of user stories and related use cases based on the pilot workflows in relation to AECO sector roles as users, provided in **Chapter 5** at user story level.
4. Delivery of a summary of the SPHERE modules and sub-modules in relation to the descriptions and inputs and outputs described in **Chapter 6.**
5. Detailed functionalities are provided for the use case as features for each sub-module of the platform, identified in **Appendix B**.
6. Delivery of Digital Twin service requirements by development of what activities would be carried out by new DT specific roles (Digital Twin Manager, Digital Twin Configuration Manager, and Digital Twin Simulation Manager), **Chapter 7 section 7.4**
7. Identification of the information flows for the user stories for each pilot, as a set of sequenced identification that provides for communication methods for users to provide interaction. These are listed as a series of inputs and outputs in the swim-lane diagrams in **Chapter 7** for each pilot and the DT service delivery.
8. A small set of initial user interface mock-ups is generated and shown in **Chapter 8** that provides for first ideas of how a user would traverse through the platform in a scenario driven manner taking into account interoperability and relationships between tools.
9. The agile development methodology connected to the cloud based XWIKI platform is described in the methodology **chapter 9**, that is further detailed in Deliverable 2.4 including the quality assurance framework for software development under SPHERE.

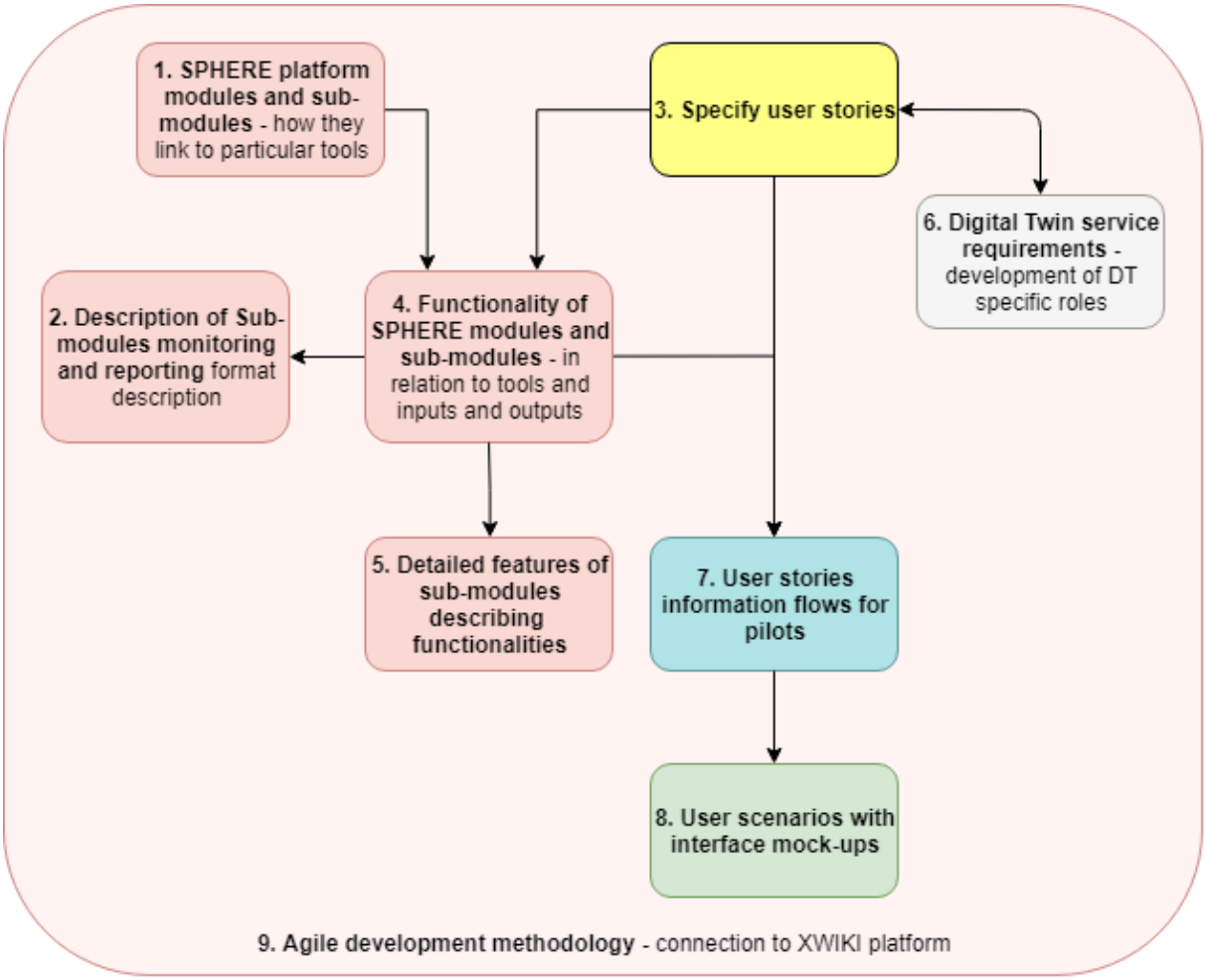


**Figure 1**. Overview of purposes of the Report as defined in DoA

## 2.2 Target Group of The Deliverable

The target group of the report is primarily the Sphere consortium of 19 partners, to inform the requirements and development of the SPHERE platform. The deliverable provides a critical overview of the integrated capabilities of the platform for further development. Other target groups that are relevant are those that can provide further feedback on the requirements of the SPHERE platform to enrich the delivery of works in this deliverable. Such target groups as identified in the communication and dissemination strategy include primarily AECOO practitioners that would form potential users of the SPHERE platform across the different life cycle phases, including architects, civil engineers, MEP engineers, construction managers, construction sub-contractors, facility managers, and building owners, among others.

## 2.3 Contributions of Partners

**Table 1.** Partner responsibilities in Task 2.3

| Tasks carried out | Chapter | Involved Partner(s) |
|---|---|---|
| Writing of Introduction | 2 | EKO |
| Development of methodologies | 3 | EKO |
| Writing of Methodologies | 3 | EKO |

| | | |
|---|---|---|
| Delivery of SPHERE Modules and Sub-Modules | 4 | EKO, review by all (EUT, BASF, R2M, NUIG, TNO, ASC, COMSA, VRM, EAI, VTT, CAV, DE5, CREE, NEX, OPY, IDP) |
| Mapping of SPHERE Pilots and Tool User Stories | 5 | EKO, EUT, BASF, R2M, NUIG, TNO, ASC, COMSA, VRM, EAI, VTT, CAV, DE5, CREE, NEX, OPY, IDP, VRM |
| Delivery of SPHERE Functionalities in activity BPMN diagrams | 6 | NEX, EKO, TNO, CAV, CREE, DE5 |
| Writing of SPHERE Agile Platform and QA Requirements | 6 | EKO |
| Setup of User Interface and User Experience Scenario Method | 7 | EKO |
| Delivery of Agile Development Methodology | 8 | EKO |
| Writing of Conclusions | 9 | EKO |
| Writing of Acronyms | | COMSA |
| Delivery of Appendix A information | App. A | EKO. NEX, DE5, CREE, CAV/VTT, TNO |
| Delivery of Appendix B information | App. B | EKO, EUT, BASF, R2M, NUIG, TNO, ASC, COMSA, VRM, EAI, VTT, CAV, DE5, CREE, NEX, OPY, IDP, VRM |
| Delivery of Appendix C information | App. C | EKO, EUT, BASF, R2M, NUIG, TNO, ASC, COMSA, VRM, EAI,VTT |

## 2.4 Baseline

The deliverable is mainly based on the inputs from the project to present, primarily the project proposal and the related DoA to evaluate the required outputs of the platform in the initial scoping, and the works carried out under Deliverable 2.1 that provides for a high-level overview of the required challenges and barriers in the construction sector to be solved by the platform. Both were utilised to integrate what functionalities would be needed to address these initial descriptions and needs as elicited.

## 2.5 Relations to Other Activities

**Figure 2.** Relation to other Tasks in SPHERE DoA

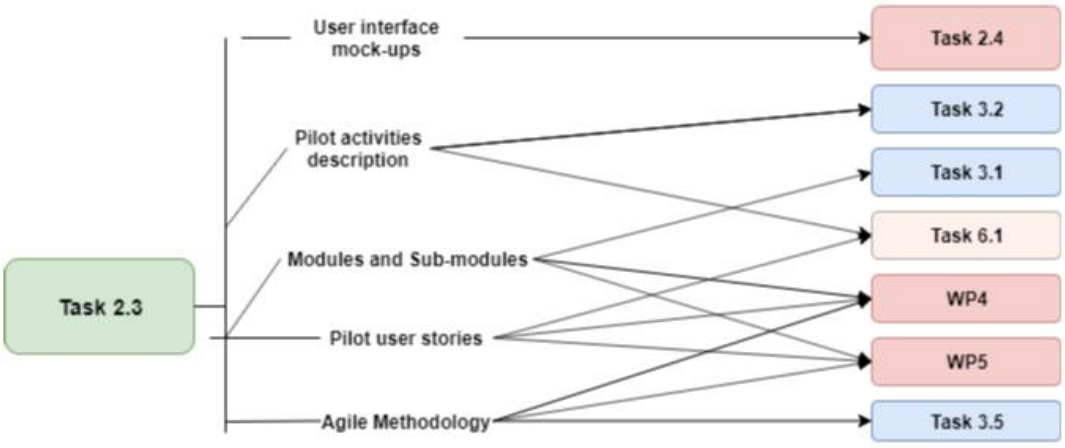

**Table 2**. Relationship between results sections in D2.3 and follow-up tasks in the SPHERE project

| Deliverable 2.3 Result | Sections | Follow-up task |
|---|---|---|
| Identification of SPHERE Platform Software Modules and Sub-modules and related technology tools from partners | Chapter 4 | WP3.1 to provide inputs in the technical requirements for the SPHERE PaaS following the sub-module breakdown, and sets of functionalities. WP4 and WP5 to help with placement of technologies within SPHERE context |
| Assessment of user stories that identify the needs for different stakeholders in the building life cycle within each SPHERE pilot for forming a pilot scenario | Chapter 5 | T6.1 start for setting up scenario of activities for demo site piloting from a 'library' of activities WP4, WP5, technology tool providers knowledge for integrating services within SPHERE piloting activities |
| Description of series of activities for each pilot and the Digital Twin integration that form functionality requirements that the SPHERE platform should deliver with information flow inputs and outputs | Chapter 6 | T6.1 start for setting up scenario of activities for demo site piloting in a sequenced manner from a managerial perspective. WP3.2 Start of setting up the data management architecture for the SPHERE DT based on defined information flows. |
| Approach for the user interface delivery of the SPHERE platform with a user scenario based wrapper interface that integrates different tool interfaces within the platform. | Chapter 7 | T2.4. for advancement of interface works based on integration with user centred design |
| Description of the Agile methodology for the delivery of the SPHERE platform during the project | Chapter 8 | T3.5, WP4, WP5 Setup of methodology for the implementation and sprint works to be carried out within the SPHERE project |
| Conclusions and recommendations for future works in the project and learnings to take on board | Chapter 9 | WP3, WP4, WP5 conclusions for specific activities and strengthening of the work-packages |
| Module and sub-module sheets that provide quick referencing for initial feature sets for software development setup | Appendix A | T3.1, T3.2, T3.4, WP4, WP5, identification of features for establishing technical requirements and implementation works for the SPHERE platform |
| Additional features for each sub-modules that were defined from the pilot aspect, with cross-checking for SPHERE software tool features, for cross-checking and evaluaton in the technical platform definitions | Appendix B | |
| Sheets that outline for each SPHERE technology tool the background capabilities to set a baseline common understanding of capabilities | Appendix C | WP3, WP4, WP5, reference information for partners to come to a consistent set of additional foreground developments of tools with their integration in the SPHERE platform |

# 3. Methodological Process

The works carried out in the deliverable served to provide a structural overview of the SPHERE platform in terms of potential sets of components (Modules and Sub-Modules) (section 3.1) and their relationship to the partner software tools (section 3.2) that are linked in terms of functionalities as describer (section 3.3). For each tool in relation to the SPHERE piloting activity a series of user stories were developed in the task (sections 3.4, 3.5, 3.6, 3.7). Together these inform the setup of different feature needs for the SPHERE platform (3.6) and related piloting functional requirements (3.8). Based on the roles relates to the user stories user scenarios can be defined (section 3.10), and a final set of Digital Twin Functional Requirements emerges (section 3.9) also defined per pilot.

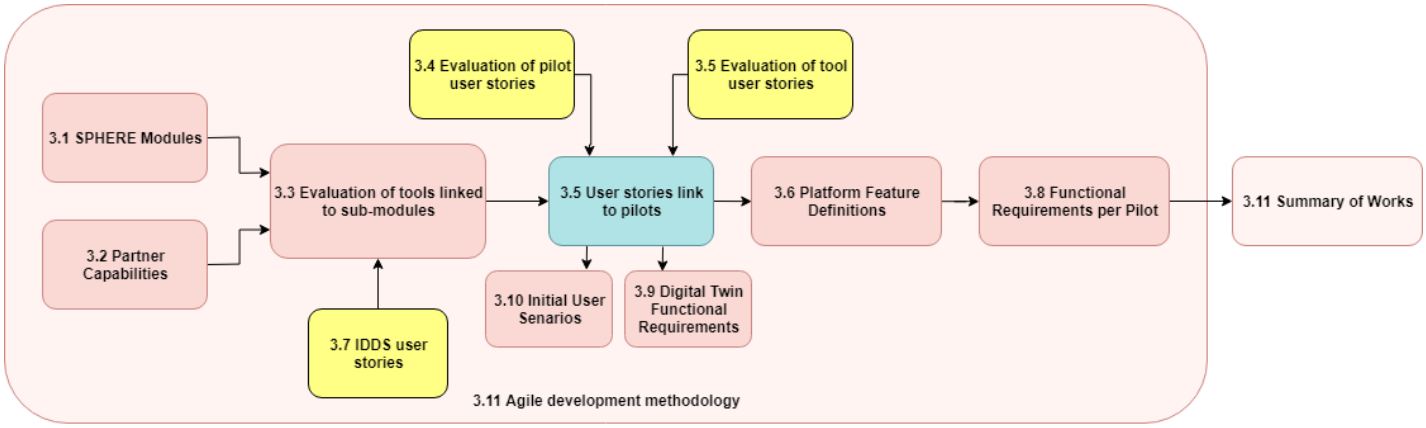


**Figure 3**. Overview of Methodological process to deliver the functionalities description for the SPHERE platform

## 3.1 Description of the SPHERE Platform Modules

The first step to provide for the requirements description of the platform was to create a listing from the project proposal of potential software components using a software engineering approach. These describe different potential functionalities that the software should perform as determined in WP2 and carried on to WP3 for refinement. To this end five main initiatives that are an umbrella of collections of functionalities for the platform were defined for the architecture:

- **Initiative 1: Horizontal Platform functions**, those functionalities needed regardless of the usage of the platform, such as user management, process workflow management, data management authorisation, and libraries.
- **Initiative 2: Brief and Target Setting,** functionalities used in the brief and target setting for the renovation or newbuild project.
- **Initiative 3: Design and Assessment Support,** functionalities used in the conceptual design and technical design phases for the renovation or newbuild project, including energy modelling and simulation and sustainability assessment
- **Initiative 4: Construction/Renovation Process management,** functionalities used in construction or renovation phase of the renovation or newbuild project, including Digital Twin blockchain services, construction operation management and document management, and the handover and commissioning.

- **Initiative 5: Use and operation support,** functionalities used in operational phase of the building including facility management, energy management and performance monitoring, and financial monitoring and accounting.

Each Initiative was subsequently split into modules and sub-modules for specific functions. The process was carried out by screening the project proposal and all listed aspects therein that would be integrated under the SPHERE project, refined in discussions in the work-package teleconferences. The evaluation resulted in a total of 18 modules and 55 sub-modules defined that are proposed for the SPHERE platform development, as listed in Appendix A and utilized in Chapters 4 and 5.

## 3.2 Definition of Existing Background Capabilities of Partners

The SPHERE platform will be composed of a combination of both new capabilities that will be developed, and existing software tools of partners in the consortium that will be integrated. The requirements analysis of the platform includes an understanding of what these tools can provide for, based on the existing state of these tools and an early overview of foreseen enhancement. To this end all tool providers were asked to provide a description of their tool in a standardised evaluation sheet, that was developed in agreement with WP4 and WP5 work-package leaders. The filled-in sheet can be found in Appendix C, and a summary of each tool and their acronym, as used in the report chapter 4 and 5 can be found in Table 3 below.

**Table 3**. A summary of the tools that will be integrated in the SPHERE platform

| Acronym | Tool name | Brief description | Tool provider |
|---|---|---|---|
| iESD_E | Intelligent Energy Designer | Intelligent Energy System Design - tool to evaluate retrofitting energy use impacts for both passive and active building parts. | Eurecat |
| iESD_W | Intelligent Water Designer | The tool will provide a recommendation of the most suitable grey water treatment technology to be used, both from an economical and environmental point of view, as well as the water availability and requirements for a given building | Eurecat |
| iPREDICT | Predictive Maintenance Tool | A predictive maintenance module based on AI and machine learning which enables to minimize downtimes due to unexpected breakdowns and reduce energy waste due to malfunctioning or misuse of equipment. Initially designed for heating and air conditioning and in water heating systems; it can be extended easily to other equipment or building elements subject to data availability, domain knowledge and users interest. | Eurecat |
| IMAN | IMAN | An issues and maintenance system for existing buildings to flag problems and help with assignment of works. The Computerized Maintenance management System (CMMS) will integrate maintenance orders triggered by predictive algorithms. | COMSA |
| HTM | Human Thermal Model | Demand-based and individual controlled methodology of thermal environments. | VTT |
| EPESUS | EPESUS | A life Cycle Assessment (LCA) software with a map-based interface that is used for material footprint and environmental assessments. | EKO |

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| CMT | Concrete Management Tool | Tool for retrofit and strength existing buildings, using composites (Externally Bonded CFRP Systems). Easy friendly used charts as a guide selector. | BASF |
| OPT | On-line Planning Tool | Linked as an external online tool OPT helps to overcome information overload issues by offering an efficient way to manage the project specifications. Additionally, incorporated BIM objects libraries and pricing information (upon request) enable construction professionals to complete project task in a shorter time. | BASF |
| FRCT | Fiber Reinforced Concrete Tool | Tool for designing Fiber Reinforced Concrete (FRC) precast panels and assess geometric and physical elements with BIM Object information output. | BASF |
| LCCCA | Life Cycle Cost Concrete Assessment | Spreadsheet Life Cycle Costing Tool for concrete that allows to compare repair and coating solutions for concrete on the basis of Life Cycle Costs (LCC), to provide a solid economic foundation to select the best repair/coating solution for an specific situation in a building | BASF |
| En-MS | Energy Management System | Tool including energy audit workflows, providing a energy planning process, objectives & targets that can be tracked, and supporting the Energy Review identifying the energy sources and related significant energy uses together with estimation of possible improvement opportunities. | R2M |
| ECOSIMPRO | ECOSIMPRO | Modelling and simulation tool for modeling 0D or 1D multidisciplinary continuous-discrete systems and any kind of system based on differential-algebraic equations (DAE) and discrete events. | EAI |
| Refurbify | Refurbify | A cloud-based platform enabling owners and suppliers to manage refurbishments, repairs and maintenance. Refurbify brings together documents, permissions, and tasks to improve quality of work, timelines, and compliance using a digital audit process. It streamlines interactions between large housing stockowners, their residents and suppliers enabling seamless collaboration in the cloud. | VRM |
| Clarity | Clarity | Using innovative 3D management dashboards, CLARITY integrates data from existing in-house sources as well as BMS, AMR, and IoT sensors to provide real-time data to monitor and improve the efficiency of networks. | VRM |
| VCMP | VCMP | A cloud-based platform enabling owners and suppliers to manage construction works. VCMP brings together specific documents, permissions, and tasks to improve quality of work, timelines, and compliance using a digital audit process. It streamlines interactions between large contractors, subcontractors and, their all off-site and on-site construction workers enabling seamless collaboration in the cloud. | VRM |
| ModSCO | ModSCO | ModSCO is the acronym for Model-Supported Control. This is a web application currently in development within the IRUSE group at NUIG. ModSCO uses Reduced Order Grey Box Models (ROM) developed with the MODELICA ® language. It offers standardized Performance Assessment Methods in order to analyse and optimize building | NUIG |

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| | | performances by: applying control settings, testing envelope retrofit packages and evaluating the savings by using a novel IPMVP method. | |
| RobMOS | RobMOS | Micro-services that can carry out dedicated energy temperature and indoor env. Quality evaluation based on a reduced order model of the building spaces, and compares it with historic data for reducing uncertainty due to variability (such as due to occupancy). | TNO |
| FLINK2GO | FLINK2GO | B2B product bringing paperless solutions to the construction site for process management focusing on detecting and correcting construction defects. | ASC |

## 3.3 Evaluation of Tools Linkage to Sub-modules

The 11 tool providers and their 18 software tools in the project will need to be able to provide for substantial additional services for the piloting of works in the project. A large amount of capabilities already exists that will be integrated in the SPHERE Digital Twin Building Platform, and some capabilities will need to be further developed. To evaluate how these will be linked into the SPHERE platform a mapping took place, where each of the sub-modules was mapped to the existing background software tools in the project where applicable, of which the results are provided in Table 5 in Chapter 4. This allows for a cleaner development and understanding of what existing functionalities exist in existing software's that are furthered in WP4 and WP5, and what new sub-modules will need to be developed under WP3. The sub-modules are subsequently used to relate them to the user stories and use cases for the SPHERE platform to identify what different users would potentially get out of the platform, and in what steps in their interaction with the platform.

## 3.4 Evaluation of Pilot User Stories From Workflows

In the works for deliverable 2.1 a series of workflows were developed for the two building renovation cases (Finland CAV and Italy DE5), and the two new build pilot cases (the Netherlands TNO and Austria CREE). These contained the stage-by-stage processes during the pilot from initial brief to design to renovate/construction to handover and in use of the buildings. Typically containing between 30 to 50 process steps across these stages, specified by sequence of occurrence and by the main role who instigates or carries out the process (including building owners' designers, construction managers, handover team, facility manager among others).

The workflows were further advanced with the pilot companies/organisations in the project (DE5, CAV, CREE, TNO) in workshops under guidance of EKO (for DE5, CREE and TNO) and VTT (for CAV), so as to improve the workflows themselves, and integrate how the SPHERE platform would potentially be used. To this end two approaches were utilised from software development practices. For each process step a user story was developed that highlighted how in each step the main user would carry out an action under a particular sub-module of the SPHERE platform (as described in section 3.1). The following format was used to this end:

"As a (user) I want to carry out (actions X, Y, Z) so as to accomplish (result A, B, C.)"

The user story sentence provides for a high-level understanding of the required functionality of the platform. The total combined listing of user stories from the pilots provides for the first step towards a blueprint of expected services to be provided for the piloting activities in the project.

## 3.5 Delivery of Tool User Stories and Linkage to Pilot User Stories

In parallel to the user stories defined from the four pilots in the SPHERE project, each of the tool providers was asked to evaluate the user stories for their tool. The analysis was requested so as to map tool specific functionalities that could be provided to particular users in a systematic manner. The process was carried out based on a standardised template as shown in Figure 4 that was generated in PowerPoint. The approach was to ask each tool provider in which particular life cycle phase of a newbuild project and/or a renovation project the tool would be used, by what type of stakeholder/user in the project, and so as to accomplish what type of result. As such a uniform set of user stories was established that can be taken forward to identify the technical requirements to implement these expected functions.

**Figure 4.** Template used to ask tool providers for user stories inputs

[TOOL] - User Stories #1

| User type<br><br>No. | As a [Role] I want to: | As a [Role] I want to: | As a [Role] I want to: | As a [Role] I want to: | As a [Role] I want to: |
|---|---|---|---|---|---|
| Strategic definition | | | | | |
| Preparation and brief | | | | | |
| Concept design | | | | | |
| Developed & technical design | | | | | |

After the tool user stories were created a cross-mapping took place, where based on the pilot user stories it was checked which tool could provide for the pilot user story functionality. As such the expected tool functionalities are directly linked to the pilot functionalities, and also pilot functionalities not provided by the software tools of the partners become apparent. The cross-check mapping is delivered in Chapter 5 in a series of pilot specific tables.

## 3.6 SPHERE Platform Features Definitions

To develop specific feature requirements for the platform the pilot companies (DE5, CAV, CREE) together with EKO and VTT held discussion in several teleconference workshops. The purpose was under each user story to identify the specific features the pilots would like to have, so as to enable the desired capabilities under the user story. As such a mapping emerges from the sub-modules that are required for each user story and the specific needs from that sub-module in terms of functionalities.

In parallel tool providers were asked to define the features for each sub-module, also based on their existing knowledge from existing background, and expertise in particular new-build and renovation processes across the life cycle. The listing of about 5 to 10 features for each sub-module provides for

a basis of starting the technical research and innovation implementation roadmap to deliver these capabilities that can be undertaken in WP3, WP4 and WP5.

Both sets of features are listed in Appendix B in a structured way for each of the sub-modules where the features are listed in a parallel manner, as shown in Figure 5 below. The parallel listing allows for crosschecking the interpretation of the sub-module, and to create a holistic overview of what should be accomplishable with the sub-module by the user. After the table was made all tool users were asked to crosscheck the features and refine them. The lists of features will require further discussion during the implementation stages to further align and provide for the technical implementation and delivery pathway under WP3.

**Figure 5**. Example of Features listing for a sub-module in the SPHERE platform.

I1.M3: Common Data Environment/Management Module

| Coding | Name | Feature from pilots | Features from software tool providers |
|---|---|---|---|
| I1.M3.SM1 NEX | Data/Document Management | | F1. Add files |
| | | | F2. Download files |
| | | P12. Management to the data/documents used for the selection of candidates,access to previous documentation during tendering (Ita US20, US21, | F3. Manage document versions |
| | | P13. Management the previous BIM data and reports (design reports, LCA,LCC),access to previous documentation (Ita US22) | |
| | | P14. Construction companies participating in the tender able to manage the previous documentation during tendering (Ita US23) | |
| | | | F4. Organize relation between documents and assets |
| | | | F5. Create relations between documents and assets |
| | | | F6. Manage sharing of documents or specific version of a document |
| | | P1. Data/document utilised by brief and target setting (Aus US1, US2, US3; Ita US1, US2 ) | |
| | | P2 access to strategic definition and survey needs data (Aus US3; Ita US2) | |
| | | P3 Access previous findings (Aus US4, US5, US23, US27, US28, US29; Ita US3, US5, US9, US26, US27, US28) | |

After both sets of features were defined a crosschecking e second step was to define the required features and interlinked

## 3.7 Analysis of the IDDS Methodology and Practices

In deliverable 2.1 of the SPHERE project a definition of the Integrated Design and Delivery Service was provided, including an synthesis of collaborative practices that define an IDDS project. The eight definitions were captured as follows:

1. Align values in a kick-off meeting that are carried out throughout the project
2. Setup performance-based goals with all parties involved with a shared responsibility
3. Select a joint business model and contract structure with shared risk
4. Establish a shared project roadmap with collaborative group updating meetings
5. Establish open communication channels and practices across involved partners
6. Methodological discovery and implementation to reach the team goals
7. Sustaining the collaboration through an experienced facilitator
8. Construction and operation considerations to optimize results and ensure objectives

To continue the integration of IDDS into the SPHERE platform a series of specific IDDS user stories were developed. These were linked to sub-modules in the SPHERE platform, and specific features to enable IDDS were elaborated upon for these sub-modules. The integration allows for setting up a

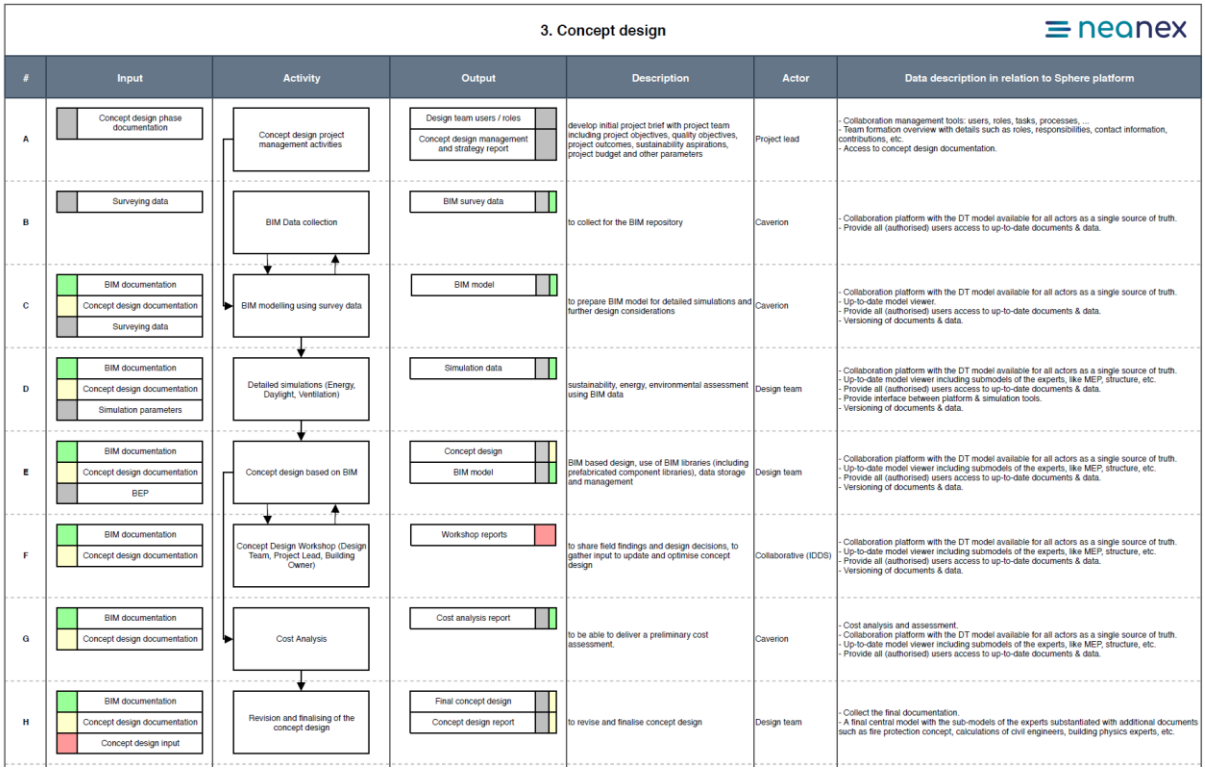
The second step was to define the required features and interlinked

## 3.8 Development of Functional Requirements Per Pilot

The delivered user stories and features described by three pilot partners (DE5, CAV, CREE) for Austria, Italy and Finland, were utilised to create a concise overview of the sequence of activities in these pilots based on the platforms. Insufficient information was made available by the Dutch pilot (TNO) at this stage of the project due to pilot consolidation challenges to create such swim-lanes, and these will be delivered at later stages.

The swim-lane diagrams developed by Neanex give an overview of each phase of the life-cycle of the activities to be carried out, the main responsible in terms of role for the activities, the input to output flow in terms of documents, data or delivered results, the related tools for the activity, and the related sub-modules for each activity. An example is provided in Figure X below. The visual diagram gives a clear overview for both the pilot partners of the steps that will be followed in their piloting, and for the tool providers in terms of the linked functionalities that will be expected and need to be developed at a high-level. The swim-lane diagrams are summarised in Chapter 7 of the report for each of the three pilots.

**Figure 6**. Example of a Pilot Swim-lane Diagram.



## 3.9 Development of Specific Digital Twin Functional Requirements

In addition to the pilot driven works a series of user stories was developed that identified specific needs for implementing Digital Twins of buildings. The collective knowledge of Digital Twins developed to present was integrated centring around three new anticipated roles for the implementation of Digital Twins as summarised in Table 4 below.

**Table 4**. Initial definition of new Digital Twin related roles and responsibilities under SPHERE

| Role | Responsibilities |
|---|---|
| Digital Twin Manager | Digital Twin Requisites settings and ICT framework design; Develop a Monitoring Strategy; Develop a Recording Strategy; Develop a Digital Twin Integrity Strategy; Setup a data analysis strategy; Supervision of Information Security management (ISO/IEC 27000); Supervision of Digital Twin Configuration Management (ISO/IEC 12207); Supervision of Digital Twin Simulation Management. |
| Digital Twin Configuration Manager | Identification and Management of roles and permits through Configuration Items (CIs); Establishment of Configuration Baselines and Configuration status availability; Set Configuration Audits and their uptake; Templating System that can be used to facilitate setting up configuration files and services; Extensibility to share custom extensions from the different agents involved; Identify potential deviations in Updating Costs beyond automations that include time, experience and training; DT system or information releases and deliveries are controlled and approved |
| Digital Twin Simulation Manager | Identify simulation strategy according to the received project and the actors involved across the lifespan of the asset, from design and construction to operation phases; Participate with the BDTManager and representative Stakeholders (Employer, BIM Manager, etc.); Identify / enhance synergies derived from collaboration between different applications and promote collaboration between them; Set simulation objectives based on the Exchange Information Requirements. |

The activities are delivered in a similar swim-lane manner in Chapter 7 section 7.4 so as to provide for a comprehensive overview of what new activities would need to be deployed under these roles to form a Digital Twin. The aim in the project is to test these new roles and their responsibilities in all the pilots, so as to provide for a first real-life testing of the procedures needed to setup, deliver and maintain a Digital Twin of a building.

## 3.10 Delivery of Initial User Scenarios and Interface Mock-ups

The SPHERE platform will be based on its diverse number of potential users and diverse set of tools and functionalities brought together, require structured setup in terms of scenario driven user interfaces and related user experiences. For each user type a different entry point and usage to the platform could exist. The different user stories provide for the baseline of such scenarios in terms of the different aspects a user would carry out, based on which an initial structure of required user interfaces can be provided. The scenario driven work was developed and is summarised in chapter 8 based on summarising the linked user stories to a particular user and developing initial archetype user interfaces that link to a particular set of sub-modules in the platform. The set of scenarios and user interface and user experience requirements with first feedbacks will be further developed in Task 2.4

## 3.11 Agile Software Development and Management

The identified platform sub-modules and provided user stories, use cases and swim-lanes provide for a working basis to further the platform development under WP3, WP4, and WP5. To support the works to be carried out in these work-packages an agile software development approach is proposed that is summarised in Chapter 9. The approach includes a suggested further break-down of sub-modules and related features into further detail, in relation to the requires user functionalities based on the user stories and use cases. It also suggests a break-down based on a sprint and agile scrum based methodology that is becoming common practice in software development, as highlighted in Chapter 9.

In parallel to the methodological description and works in this report, an open accessible collaborative platform was launched (XWIKI) for the SPHERE project that contains the contents of this report. The XWIKI tool will be used to consolidate the knowledge generate to present SPHERE project that can be updated in an agile manner and enhanced as the project progresses. It can also be used to identify and map specific sprints, as needed using the agile methodology. Its specific use and updating procedures are described in Deliverable 2.4 that also provides an overview of the information captured to present in the platform. The SPHERE XWIKI is available only to members of the consortium given the development nature of the knowledge therein.

## 3.12 Summary of Works to Deliver Functional Requirements

The combination of the developed content in terms of sub-modules, user stories, feature based use cases, and summary swim-lanes is synthesized in Chapter 10 of the report. The chapter summaries the achievements made in this report and how they can be utilised in the development of the SPHERE platform. How these should be taken up in continued developments of further tasks in the SPHERE platform, as also identified in section 2.5, and what lessons were learnt from the process of the works under this deliverable. Of particular relevance is the Agile software development methodology as highlighted earlier in Chapter 9.

# 4 SPHERE Functionality Requirements

The project consortium carried out a mapping of the functionalities to be provided by the platform divided into different platform building blocks. To this end a software engineering structure was adopted that divides the platform into initiatives, modules and sub-modules to create a hierarchical structure that clusters different functionalities. A summary Table 5 is provided that summarises the expected sub-modules of the platform for horizontal needs like user management, data and document storage, and specific needs such as energy assessments or operational contractual requirements checking for energy performance contracts. The table also includes identification of the software tools by different partners in the project that will be linked into a sub-modules. Finally, a summary is provided of the number of user stories that were identified by the pilot were use is made of a particular sub-module. This shows that the Austrian and Italian pilot by CREE and DE5 will integrate detailed pilots in terms of usage of the full spectrum of the SPHERE platform, whilst the Finnish and Netherlands pilots will utilise a small sub-set of capabilities of the platform.

**Table 5**. Summary of platform modules, sub-modules and generated SPHERE user stories from pilots and software tools

| Coding | Name | Description of functionalities | Respective partners | Associated Tools | WP | No pilot user stories linked to sub-module (A – Austria, I – Italy, F- Finland, N - Netherlands) |
|---|---|---|---|---|---|---|
| **Horizontal Platform Functions** | | | | | | |
| ***I1.M1*** | **1. User and Network Management Module** | | | | | |
| *I1.M1.SM1* | 1. Identify Users | Registration and access rights assignment of platform users by a platform administrator | VTT, NEX, VRM, ECO, IDP, ASC | Refurbify, FLINK2GO | WP3 | 6(A)+12(I)+1(F)+ 0(N) |
| *I1.M1.SM2* | 2. Create Project & Identify Roles | Identify and assignment of user roles in newly created/existing project by a project manager | VTT, NEX, VRM, ECO, IDP, ASC | Refurbify, FLINK2GO | WP3 | 6(A)+12(I)+0(F)+ 0(N) |
| *I1.M2* | **2. Processes and Workflows Management Module** | | | | | |
| *I1.M2.SM1* | 1. Setup and Management of Project Phases and Processes | Outline and set up the activities in a new build/renovation project by selecting project phases and the activities/processes in each phase in a configurable manner | VTT, NEX, VRM, ECO, IDP | OPT, LCCCA, CMT, Refurbify | WP3 | 2(A)+7(I)+ 0(F)+ 0(N) |
| *I1.M2.SM2* | 2. Roles and Processes Matching | Identify roles to related processes. Enable skills-based access to job/process types based on roles. | VTT, NEX, VRM, ECO, IDP, ASC | Refurbify, FLINK2GO | WP3 | 5(A)+13(I)+ 0(F)+ 0(N) |

| | | | | | | |
|---|---|---|---|---|---|---|
| *I1.M2.SM3* | 3. Authorisation | Roles-based notifications related to job progress. Off-site issue management and job approval. | VTT, NEX, VRM, ECO, IDP, ASC | Refurbify, FLINK2GO | WP3 | 6(A)+14(I)+ 0(F)+ 0(N) |
| *I1.M2.SM4* | 4. IDDS Guidelines, Roles and Information flows sharing module | Setup and management of Integrated Design and Delivery Services (IDDS) workflows by a series of guidelines and user roles and processes if a project is carried out with an IDDS structure (integrated AECOO teams, information sharing across life cycle, joint-contracting, joint-risk sharing) and bringing together the Digital Twin information flows for supporting IDDS practices. | EKO, OPY, IDP | NEW TOOL | WP3 | TBD |
| ***I1.M3*** | **3. Common Data Environment/Management Module** | | | | | |
| *I1.M3.SM1* | 1. Data/Document Management | Secure and organised document input, output and storage. Addition of metadata describing document contents. Management of document access in the CDE. | VTT, NEX, VRM, ECO, IDP | Refurbify | WP3 | 31(A)+33(I)+3(F)+1(N) |
| *I1.M3.SM2* | 2. Connectivity to IoT and External Live Sources | The IoT platform will allow the use of a range of sensors that will provide the metrics required by the DT platform to perform a variety of functions. The captured data is used for allowing trends over time analysis and provide the required amount of data for predictive maintenance. | VTT, NEX, VRM, ECO, IDP | Clarity | WP3 | 1(A)+1(I)+ 0(F)+ 0(N) |
| *I1.M3.SM3* | 3. Exporting/Allow Access/Deletion of Data and Documents | View data within and outside to third parties to the platform. Select data and document and export via excel, csv, pdf etc. Allow deletion of data and document in compliance with GDPR. | VTT, NEX, VRM, ECO, IDP | Clarity | WP3 | 14(A)+10(I)+2(F)+ 0(N) |
| *I1.M3.SM4* | 4. Dynamic Data Visualisation | Utilise live or near-live data and represent the data visually in diagrams and tables for the platform user in a manner, which enhances their understanding, enables actions. | VRM, ASC | Clarity, FLINK2GO | WP3 | 14(A)+7(I)+2(F)+ 0(N) |
| *I1.M3.SM5* | 5. Reporting | Parameter and metric based reports generation, configurable for each life cycle phase with related processes and reportable benchmarked, performance and other outputs. | VRM | Clarity | WP3 | 29(A)+32(I)+1(F)+ 0(N) |
| ***I1.M4*** | **4. BIM and Objects Libraries Module** | | | | | |
| *I1.M4.SM1* | 1.BIM Execution Plan | Enhancement of project process workflow with BIM exchange information requirements and metadata needs in relation to roles and responsibilities as specified in BIM execution plan. Provides a high-level guidance for the setup of a BEP. | IDP | NEW TOOL | WP3 | 7(A)+11(I)+ 0(F)+1(N) |
| *I1.M4.SM2* | 2. BIM and Objects Libraries | Digital Twin libraries. Open Software In the Loop BIM object libraries connections with a manual selection option to enrich IFC instances (for example used for indoor environment simulation and analysis.) | IDP, NEX | OPT | WP3 | 19(A)+14(I)+ 0(F)+ 0(N) |
| *I1.M4.SM3* | 3.Material Library | Material libraries are collections of materials, from different manufacturers. SPHERE material library allows user to assign materials to BIM objects without browsing for other databases. In addition to physical (density, specific heat, thermal conductivity etc.) and chemical properties (toxicity, chemical stability etc.), cost information will be available in SPHERE material libraries. The availability and the integration of the material library facilitate the creation of Bill of Quantities (BoQ) and simulations. | EKO | OPT | WP3 | 12(A)+13(I)+ 0(F)+ 0(N) |
| *I1.M4.SM4* | 4. HVAC Library | Library for the simulation of HVAC systems in EcosimPro simulation platform. It will allow the user to model the HVAC system connecting components from the library with the objective of analysing the system performance. | EAI | EcosimPro, RobMOS | WP3 | 13(A)+14(I)+ 0(F)+ 0(N) |

| | | | | | | |
|---|---|---|---|---|---|---|
| *I1.M4.SM5* | 5.Thermal and Fluid Component Libraries | Libraries for the simulation of the building in EcosimPro simulation platform. They will allow the user to model the passive elements (walls, windows, etc ) of the building and the heat transfer phenomena The module includes also the fluid properties calculation for HVAC library. | EAI | EcosimPro, RobMOS | WP3 | 11(A)+12(I)+ 0(F)+ 0(N) |
| ***I1.M5*** | **5. Procurement and Contracting Module** | | | | | |
| *I1.M5.SM1* | 1. Tendering Functionalities | Based on the previous reports (brief and strategic definition, early concept design draft, basic cost estimation reports) provide for a search among listed performance ranked service and or component suppliers as a first selection to invite to tender. | VRM, EKO | Refurbify (Potentially) | WP3 | 6(A)+10(I)+4(F)+3(N) |
| | **Brief and Target Setting** | | | | | |
| ***I2.M1*** | **Brief and Target Setting Module** | | | | | |
| *I2.M1.SM1* | 1. Brief Definition | Setup of a structured form for defining a brief that results in a brief report. Selection options based on standardised typologies for renovation and newbuild informed by BIM IFC standards. Ability to link documents and other projects information as examples. | EKO | NEW TOOL | WP3 | 2(A)+1(I)+ 0(F)+ 0(N) |
| *I2.M1.SM2* | 2. Target Setting & Collaborative Management | Selection of KPIs for the project performance targets in relation to the workflow process, including whole-life costing, durability, lifespan and maintenance environmental sustainability and standards, and energy usage targets. Setting of the KPI goals to be achieved. Ability to track targets collectively by adding information to track targets development. | EKO | NEW TOOL | WP3 | 13(A)+11(I)+3(F)+2(N) |
| *I2.M1.SM3* | 3. ESCO Operational & Contractual Responsibilities | Tracking module in which the apartment owners and ESCO detail rights and obligations and can track the responsibilities during the contract term (operational guarantee from client side, guaranteed savings and guaranteed performance from ESCO side, ESCO technical support etc.). | R2M | En-Ms | WP3 | 0(A)+0(I)+ 0(F)+2(N) |
| | **Design and Assessment Support** | | | | | |
| ***I3.M1*** | **1.Energy Modelling and Simulation Module** | | | | | |
| *I3.M1.SM1* | 1. Settings and Parameters: Temperature, Indoor Environment Quality Control (Comfort) | Serves to set the occupant operational parameters requirements for different spaces and durations in the building including temperature set points, indoor environment quality needs, and occupancy. Informed by type of building and usage, and when available for existing buildings by historic data. | TNO, EKO | RobMOS HTM | WP4 | 4(A)+4(I)+ 0(F)+4(N) |
| *I3.M1.SM2* | 2. Targets and Metrics | Allows for selection of specific energy KPIs/metrics and targets to be achieved in relation to regulatory requirements (U-values, nZEB buildings) differentiated between countries. | TNO, EKO | All energy tools | WP4 | 4(A)+4(I)+2(F)+4(N) |
| *I3.M1.SM3* | 3. Heat Load Modelling | Utilisation of building BIM data combined with weather information, semantic heat load information and occupancy values to model the expected heat usage in a new or existing building over time at aggregate level and for each space | TNO, EAI, NUIG | ModSCO, RobMOS, EcosimPro | WP4 | 4(A)+4(I)+ 0(F)+4(N) |
| *I3.M1.SM4* | 4. Renovation Energy Assessment | Evaluate the impact of different building envelope renovation (ModSCO) and building envelope and HVAC renovation (EcosimPRo) scenarios on the energy use and indoor environment quality using predictive algorithms, taking into account weather data and | EAI, NUIG | ModSCO, EcosimPro | WP4 | 4(A)+2(I)+ 0(F)+4(N) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | historic data for calibrations or using physics based models of the building and HVAC (EcosimPro). In the former, the simulation model may include building, HVAC and control, allowing the user to carry out a functional assessment of the system. | | | | |
| *I3.M1.SM5* | 5. Energy Efficiency and Supply | Calculates and evaluates the energy requirements of the building (heating, cooling, hot water, and lighting) and determine the most efficient energy supply equipment to be installed in the building, based on its demand profiles. | EUT | iESD_E | WP4 | 4(A)+2(I)+ 0(F)+4(N) |
| *I3.M1.SM6* | 6. Micro-services for Energy Modelling Calibration and Validation | Provides a calibration service to evaluate from building BIM data and historic energy and/or environmental quality data the forecasted temperature and thermal values. | TNO | RobMOS | WP4 | 4(A)+4(I)+ 0(F)+4(N) |
| *I3.M1.SM7* | 7. Human Thermal Model | Provides for a fine-grained estimation of temperature needs in a building for each space based on space data (temperature, air velocity, relative humidity) and occupant specific scenarios (metabolism, clothing insulation) to estimate reasonable operational temperature needs. | VTT | HTM | WP4 | 4(A)+ 4(I)+ 0(F)+ 0(N) |
| ***I3.M2*** | **2. Sustainability Assessment** | | | | | |
| *I3.M2.SM1* | 1.Material Flow Management | Provides for an evaluation of the material footprint of the building by generation of a Bill of Quantities from a BIM file with additional semantic data, either manually added or based on standardised building typologies. | EKO | EPESUS | WP4 | 4(A)+3(I)+ 0(F)+ 0(N) |
| *I3.M2.SM2* | 2.Life Cycle Impact Assessment | Evaluates the environmental impacts of the building for a range of relevant KPIs, by drawing upon the bill of quantities data, with linkages to LEED and BREEAM assessment needs. | EKO | CMT, EPESUS | WP4 | 4(A)+2(I)+ 0(F)+ 0(N) |
| *I3.M2.SM3* | 3.Life Cycle Costing Analyses | Evaluates the life cycle costing of the building based on the associated costing data in the BIM file (where available) and/or manually added data for specific building components and processes costing. Includes estimations of the operational costs of building operations and maintenance, to come to full life cycle costs. | EKO | LCCCA, EPESUS | WP4 | 4(A)+2(I)+ 0(F)+ 0(N) |
| *I3.M2.SM4* | 4.Circularity Assessment | Evaluates deconstruction scenarios for the building based on the material footprint by evaluating the recyclability and re-usability of different simple components, based on linkage to a deconstruction technology and practice database. | EKO | EPESUS | WP4 | 4(A)+3(I)+ 0(F)+ 0(N) |
| *I3.M2.SM5* | 5. Water treatment assessment | Calculate and evaluate the water availability (greywater and rainwater) and water requirements of the building (related to irrigation and toilet discharge) and evaluate which water treatment technology is the most suitable to install in the building according to its climatic condition, use, architectonic characteristics and its requirements (irrigation, toilet discharge). Determine the optimal sizing of the technologies based on the building's conditions. | EUT | iESD_W | WP4 | 0(A)+0(I)+ 0(F)+ 0(N) |
| | **Construction/Renovation Process Management** | | | | | |
| ***I4.M1*** | **1.Blockchain Services for the Construction Processes Module** | | | | | |
| *I4.M1.SM1* | 1.Time stamping/ Versioning for Digital Twin Certification | Provides for a set of automated rules to provide for versioning of the Digital Twin (potentially as a blockchain checked unique entry logbook), required for legal purposes | IDP | NEW TOOL | WP3 | 6(A)+9(I)+ 0(F)+ 0(N) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | of identifying the incoming, storage, and outgoing data at set points based on sets of IoT data (completeness) and enrichment (BIM data additions) | | | | |
| *I4.M1.SM2* | 3.Subcontracting Management | Allow managed access to the platform by approved sub-contractors. Restricted view of project in line with main contractor's wishes | EUT, VRM | Refurbify | WP3 | 1(A)+9(I)+ 0(F)+ 0(N) |
| ***I4.M2*** | **2.Construction Operation Management Module** | | | | | |
| *I4.M2.SM1* | 1.Site Role/Task Management | Ensure role and skills are combined to restrict or correctly allocate site based tasks to different involved construction workers and companies. | CREE, ASC, VRM | Refurbify, FLINK2GO | WP5 | 6(A)+7(I)+1(F)+ 0(N) |
| *I4.M2.SM2* | 2.Site Surveys and Inspection | Site-based operatives receive and undertake works via application. Desk based operatives approve/reject site issues as appropriate | CREE, ASC | Refurbify, FLINK2GO | WP5 | 3(A)+7(I)+ 0(F)+2(N) |
| *I4.M2.SM3* | 3.Clash Detection Solving and Documenting | Links to a clash detection software to evaluate different versions of the BIM files and data entries for delivered supplier components on-site, related to the versioning benchmark and their consistency or differences. | CREE, ASC | External tool integration (TBD) | WP3 | 2(A)+0(I)+ 0(F)+ 0(N) |
| *I4.M2.SM4* | 4.Progress Monitoring | Delivers a timeline of the construction process based on the workflow and set of related activities, with a monitoring progress status based on site manual and IoT information inputs | CREE, ASC | Flink2GO | WP3 | 6(A)+8(I)+2(F)+ 0(N) |
| ***I4.M3*** | **3.Construction Document Management** | | | | | |
| *I4.M3.SM1* | 1.Design-As Built Data Compliance | Provides for a checker that evaluates that the final "As-built" documentation is adequately completed based on a minimum set of data requirements for different BIM versions (3DBIM, 4DBIM etc.) with the semantic data needs, manual data entries, and IoT datasets of the construction process for the Digital Twin. | EKO | TBD – external tool | WP3 | 4(A)+3(I)+1(F)+2(N) |
| *I4.M3.SM2* | 2.Improving the Process of Change Management | Define a structured approach to setup collaborative documentation sharing, covering folder structures, secure upload of documents, file meta-data entry, author tracing, and easy retrieval. | NEX, VRM, FLINK2GO | Refurbify | WP3 | 4(A)+7(I)+ 0(F)+ 0(N) |
| ***I4.M4*** | **4.Regulatory Compliance Module** | | | | | |
| *I4.M4.SM1* | 1. Regulation and Compliance Checks | Coordination of all of the onsite activities required whilst also enforcing the regulatory and compliance requirements that are programmed on the VCMP's regulations datastore | VRM | VCMP | WP3 | 7(A)+11(I)+ 0(F)+ 0(N) |
| ***I4.M5*** | **5.Comissioning** | | | | | |
| *I4.M5.SM1* | 1. Comparison of Energy Simulation and Real Values | Evaluation of the energy use and temperatures in the building for different spaces during commission under controlled conditions with IoT measurements, with comparison of simulated values during the design and construction phases, including feedback for parameter improvements for future simulations. | EKO, TNO, EAI, VRM | RobMOS, EcosimPro | WP4 | 1(A)+1(I)+1(F)+1(N) |
| *I4.M6* | **6.Handover Management Module** | | | | | |
| *I4.M6.SM1* | 1.Handover Data Management | Coordinate handover through approval or re-works processes. Enable online collaborative handover documentation review. | NEX, VRM | Refurbify | WP5 | 3(A)+3(I)+1(F)+ 0(N) |
| | **Use and Operation Support** | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***I5.M1*** | **1. Facility Management Module** | | | | | |
| *I5.M1.SM1* | 1. Organizing Maintenance Schedules | Time-based or expiry date maintenance documentation needs and works function, that provides based on a scheduling and micro-service event-based updates for maintenance needs. | IDP, EUT, VRM | LCCCA, Refurbify | WP5 | 2(A)+2(I)+ 0(F)+ 0(N) |
| *I5.M1.SM2* | 2. Decision Making for Refurbishment | Tool for developing a decision support system for the selection of the construction elements for renovations of the building, from the point of view of passive solutions (e.g. focused on façade, cover, solar protection, etc.), as well as active solutions (e.g.: selection of energy supplies, energy production and conversion equipment, heat radiators, etc.) necessary for the supply and satisfaction of the energy requirements of the building. | NUIG,BASF | LCCCA, OPT, FRCT, ModSCO (only Passive) | WP5 | 2(A)+2(I)+ 0(F)+ 0(N) |
| *I5.M1.SM3* | 3. Building Issue Management | Issue facility enabled to allow site-based operatives to undertake issue resolution works, and/or raise new jobs based on issues discovered on site during the course of their task execution | VRM, ASC | Refurbify, FLINK2GO | WP5 | 2(A)+2(I)+1(F)+ 0(N) |
| *I5.M1.SM 4* | 4. Big Data Analytics for Predictive Maintenance | Tool to trigger early warnings to enable the shift from preventive maintenance to predictive maintenance. The main target are the most energy-demanding appliances in the domestic sector, namely heating and cooling systems and water heaters, but potentially extended to other maintenance topics related to safety (structural stability), leaks (electricity, gas, water). | COMS, EUT | IMAN,iPredict | WP5 | 2(A)+2(I)+ 0(F)+ 0(N) |
| ***I5.M2*** | **2. Energy Management and Performance Monitoring** | | | | | |
| *I5.M2.SM1* | 1. Data Acquisition and Status Reporting | Integration of IoT sensor systems in building energy management systems for operational data capture and acquisition into the platform, within a standardised status reporting of aggregated data over time and per dwelling/space. | DE5, VRM | Clarity | WP5 | 1(A)+1(I)+ 0(F)+2(N) |
| *I5.M2.SM2* | 2. Dynamic Env. Assessment and Communications | Provides for an evaluation of the renovation performance in a dynamic manner, by enabling the rapid generation of an environmental and circularity renovation profile including waste generation and management needs | EKO | EPESUS | WP4 | 1(A)+1(I)+2(F)+ |
| *I5.M2.SM3* | 3. Energy Use Optimisation | Calculates and evaluates the energy requirements of the building (heating, cooling, DHW and lighting). Then, it studies potential passive and active solutions to be installed in the building and analyse their impact in terms of energy, costs and sustainability. Determine the most efficient equipment to be installed in the building, based on its demand profiles and building's conditions. | EUT, TNO,EKO, EAI | ModSCO, iESD_E, RobMOS, EcosimPro | WP4 WP5 | 1(A)+ 1(I)+ 0(F)+2(N) |
| *I5.M2.SM4* | 4. Energy Generation Evaluation and Decision Support | Evaluates which renewable energy technology is the most suitable to install in the building according to its climatic condition, use and architectonic characteristics (e.g. available surface for panels). | EUT | iESD_E, | WP4 | 1(A)+ 1(I)+2(F)+3(N) |
| *I5.M2.SM5* | 5. Human Thermal Model Building Automation Control | Improves thermal satisfaction of occupants and energy efficiency of building, by a new demand based thermal comfort concept which monitors relevant space and occupant data estimates, incl. thermal sensation index values for each occupant and space, and defines optimal temperature set-point values for space control units on-line. Energy efficiency is improved by avoiding unnecessary heating/cooling when spaces are unoccupied. Provides occupant app-based feedback options | VTT | HTM | WP5 | 1(A)+ 1(I)+ 0(F)+0(N) |

| | | | | | | |
|---|---|---|---|---|---|---|
| *I5.M2.SM6* | 6. Energy Management ICT tool – ISO 50001 Decision | Energy Management tool including support for ISO 50001 and Energy audit workflows, which brings together energy decision support data from other tools. Provides for a standardised energy planning process, which is a key step in establishing an EnMS, supports the Energy Review process though assessment of the energy Sources and Energy uses building on data from other tools, to be analysed for easy identification of any related *Improvement Opportunities*. Finally providing for defining action Plans and objectives & targets that can be tracked. | R2M, VRM | En-MS | WP5 | 1(A)+ 1(I)+ 0(F)+ 0(N) |
| *I5.M2.SM7* | 7.Reporting | Provides for a reporting standard that integrates different tool outputs for the environmental and energy management and decision support. | IDP, DE5, EKO | Overlay of different tools | WP5 | 1(A)+ 1(I)+ 0(F)+ 0(N) |
| ***I5.M3*** | **3. Financial Monitoring and Account Keeping Module** | | | | | |
| *I5.M3.SM1* | 1. Smart Contract Based Open Ledger Bookkeeping Module for **Renovation** | Translation of renovation contractor and sub-contractor contracts once awarded into smart contracts using blockchain to identify milestones to specific events that can be automatically monitored using the digital twin to notify the contractor of accomplishment for intermediary awarding of funds. Identification of parties that would share the blockchain for immutability and legal requirements. | EUT, EKO | NEW TOOL | WP5 | 1(A)+ 1(I)+ 0(F)+ 0(N) |
| *I5.M3.SM2* | 2. Smart Contract Based Open Ledger Bookkeeping Module for **Construction** | Translation of construction contractor and sub contractor contracts once awarded into smart contracts using blockchain to identify milestones to specific events that can be automatically monitored using the digital twin to notify the contractor of accomplishment for intermediary awarding of funds. Identification of parties that would share the blockchain for immutability and legal requirements. | EUT, ASC | NEW TOOL | WP3 | 3(A)+6(I)+ 0(F)+ 0(N) |
| *I5.M3.SM3* | 3. Evidence Recording and Tracing | Provides for comparison of the Digital Twin versions and related performance evidence differences for financial contract verification purposes. Integrates time-stamping (recording) and tracing between versions. | IDP, EUT | NEW TOOL | WP5 | |

# 5 SPHERE Pilot and Tools Use Cases and User Requirements

The chapter provides an overview of the user stories developed by the SPHERE pilot partners (CAV, DE5, CREE, TNO) and the software tool providers EUT, COMSA, VTT, EKO, BASF, R2M, EAI, VRM, NUIG, TNO AND ASC. User stories are provided for each pilot per required phase in separate tables, with overlays related to tools and tool providers mapped in Green colour, additional non-matching user stories suggested by tool providers in grey colour, and additional non-matching user stories suggested by pilots in light orange colour. The pilots are presented under each section split by the Strategic Definition (5.2), Preparation and brief (5.3), Concept and Technical design (5.4), Construction/Renovation (5.5), Handover and commissioning (5.6) and in use phase (5.7). Note that in each table the user stories identified by both pilots and tool providers are displayed in **GREEN**, additional user stories suggested by tool providers are displayed in **GREY** that are not suggested/use by the specific pilot at present, and finally in **YELLOW** are user stories suggested by the pilot but not by tool providers.

## 5.1 User Stories for IDDS instead of Design-Bid-Build Contracting

As a premise, BIM should be used, as the main tool to link actors, disseminate information and present the transparency of the team's progress and the Integrated Design and Delivery Services (IDDS) Manager should organise and facilitate these activities. The IDDS Manager should be chosen among the technical stakeholders (design team, DT manager, BIM Manager etc.).

**Table 6**. User Stories for the Implementation of Integrated Design and Delivery Services

| US | As a | During | I want to | And I need to involve |
|---|---|---|---|---|
| IDDS. 1 | IDDS Manager | Strategic Definition | • Organize a **Value Workshop** to promote the Owner/Core Team Alignment and foster creativity and inter-disciplinary thinking.<br>• Present to the collaborative team the client's business case and strategic brief to work on the project programme from this new point of view.<br>• Establish a foundation by setting fees to provide appropriate incentives to the involved team. | Building Owner, Project Manager, Construction Manager, Architect/Designer, BIM/DT Manager, Engineer, MEP Engineer, Build Automation Team, Tenant. |
| IDDS. 2 | IDDS Manager | Preparation & Brief | Organize a **Negotiation Workshop** to align the team, agree on values and common goals and **Evaluate:**<br>• Identification of client's needs and objectives, business case, sustainability, life cycle and facilities management aspirations and possible constraints on development.<br>• Preparation of feasibility studies and assessment of options to enable the client to decide whether to proceed.<br>**Design Brief considering:**<br>• Develop client's initial statement of key requirements and constraints. Define procurement method, project sustainability and BIM procedures, building design lifetime and project organizational structure and range of consultants and others to be engaged for the project, including their definition of responsibilities. | Building Owner, Project Manager, Construction Manager, Architect, Design Lead, BIM/DT Manager, Engineer, MEP Engineer, Build Automation Team, Tenant, Surveyor, Const. Sub-contractor. |

| | | | | |
|---|---|---|---|---|
| | | | • Work on IPD Pre-Contracting selection to agree a base fee with contingent-on-success profits.<br>• Determine the project budget. | |
| IDDS. 3 | IDDS Manager | Concept Design | • Organize the **Collaborative Design Team Workshop**.<br>• Design Product & Process simultaneously.<br>• Organize BIM pre-start meeting.<br>• Enable design team access to BIM data.<br>• Share initial model with Design Team for strategic analysis and options appraisal.<br>• Use BIM data for environmental performance and area analysis, simulations, etc.<br>• From the beginning try to identify possible waste.<br>• Organize smaller, focused meetings for specific issues. | Construction Manager, Architect/Designer, Engineer, MEP Engineer, BIM/DT Manager, Contractor, Build Facility Manager, Build Automation Team, Design Lead, Design Team, Design Expert, Site Manager, Project Manager, BIM Manager. |
| IDDS. 4 | IDDS Manager | Dev. & Tech Design | Promote the **Lean Design Team Workshop**:<br>• Organize in cross-functional teams.<br>• Minimize negative iteration.<br>• Use technologies that facilitate Lean Design.<br>• Use the Last Planner system of production control.<br>• Define contracting methodology through advances and definitions in design and management. | Precast Producer, Building Owner, Maintenance Service Company, Digital Twin Conf. Man., Architect/Designer, Engineer, MEP Engineer, BIM/DT Manager, Contractor, Build. Facility Manager, Build Automation Team, Design Lead, Design Team, Site Manager, Project Manager Project Lead. |
| IDDS. 5 | IDDS Manager | Construction /Renovation | Organize regular W**orkshops for Collaborative Construction/Redesign Teams.**<br>• Apply Lean Construction methodology.<br>• Reinforce communications to keep the synergy of the collaborative team.<br>• Assign a facilitator/Last Planner to assume coordination tasks during the length of the project.<br>• Clarification and resolution of design queries as they arise.<br>• Assist with preparation for commissioning, training, handover, future monitoring and maintenance. | Concrete Producer, Construction Manager, Contractor, Certification Consultant, Surveyor, Project manager, Construction Lead, Subcontractors, Build Automation Team, Suppliers, General Contractor, Commissioning Team, |
| IDDS. 6 | IDDS Manager | Handover & Close Out | • Reduce handover time through IDDS principles and BIM technologies.<br>• Discover possible problems in future management till completing the lifecycle of the building.<br>• Administrate the building contract after practical completion and making final inspections.<br>• Assist building uses during initial occupation period.<br>• Review of project performance "in use" and comparison with BIM data. | Build. Automation Team, Maintenance Service Company, Build. Facility Manager, Surveyor, Project Manager, Constr. Sub-contractor, Building Owner, Design Team, Construction Manager |
| IDDS. 7 | IDDS Manager | In Use Phase | **Sustain the Collaboration:**<br>• Review with the Construction team their roles and responsibilities after construction.<br>• Continue tracking performance and monitoring key performance indicators for the life of the building.<br>• Coordinate commissioning: the installation of all systems by the Constructor is subject to performance goals, and commissioning is incorporated into the construction schedule.<br>• Verify the training of the building operations team at the end of the construction.<br>• Roll a percentage of performance savings into operations optimization.<br>• Establish standard operating procedures that provide continuous feedback.<br>• Communicate the building's green features & performance goals to occupants to gain their support and buy-in. | Build Facility Manager, Maintenance Service Company, BIM Manager, Digital Twin Simulation Manager, Building Owner, Build Automation Team, Tenant, Contractor, Const. Sub-contractor, Architect/Designer, Certification Consultant, Surveyor, Project Manager, Facility Manager, BIM Manager, Building Automation. |

## 5.2 Pilot and tool user stories for the Strategic Definition

**Table 7.** User Stories for Strategic Definition for Austrian pilot by CREE

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| BO.1 | Building Owner | Strategic definition | Evaluate which renewable energy technology is the most suitable to install in the building | I3.M1 | SM4 | iESD_E |
| BO.2 | Building Owner | Strategic definition | Evaluate which water treatment technology is most suitable to install in the building | I3.M2 | SM5 | iESD_W |
| BO.3 | Building Owner | Strategic definition | Obtain additional value from improved occupant satisfaction and energy efficiency | I3.M1 | SM7 | HTM |
| BO.4 | Building Owner | Strategic definition | Compliance with current regulations on building maintenance, demand a maintenance plan in the project | I4.M4 | SM.1 | IMAN |
| BO.5 | Building Owner | Strategy definition | Identify the overarching objective and performance criteria | I2.M1 | SM1/SM2 | |
| PM.1 | Project Manager | Strategic definition | Set in the brief the environmental and/or circularity targets for a renovation or new build project | I2.M1 | SM2 | EPESUS |
| PM.2 | Project Manager | Strategic definition | To comply with the provisions of the building owner for the project design team (architects and engineers) | | | IMAN |
| CM.1 | Construction Manager | Strategic definition | Help to implement economic and environmental improvements to enhance competitiveness | I2.M1 | SM1/SM2 | CMT |
| DT/BIM.1 | BIM / DT Manager | Strategic definition | Ensure that the BIM LOD level and DT software are compatible with the CMMS | I1.M3 | SM2 | CMT |
| C.1 | Contractor | Strategic definition | Deliver read-to-use input data for green building rating schemes to clients (DGNB, BREEAM, HQE and LEED) | I1.M3 | SM5 | CMT |
| A/D.1 | Architect /Designer | Strategic definition | Add value to buildings thanks to the quantification of environmental performance | | | CMT |
| A/D.1 | Architect /Designer | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I5.M2 | SM4 | En-MS |
| Eng.1 | Engineer | Strategic definition | Add value to buildings thanks to the quantification of environmental performance | | | CMT |
| MEP.1 | MEP Engineer | Strategic definition | Evaluate which renewable energy technology is the most suitable to install in the building | I3.M1 | SM4 | iESD_E |
| MEP.2 | MEP Engineer | Strategic definition | Determine the optimal sizing of renewable energy technologies based on the building conditions | I3.M1 | SM4 | iESD_E |
| MEP.3 | MEP Engineer | Strategic definition | Evaluate which water treatment technology is most suitable to install in the building | I3.M2 | SM5 | iESD_W |
| MEP.4 | MEP Engineer | Strategic definition | Determine the optimal sizing of water treatment technology based on the building conditions | I3.M2 | SM5 | iESD_W |
| MEP.5 | MEP Engineer | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I5.M2 | SM4 | En-MS |
| BA.1 | Build. Automation Team | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I5.M2 | ESM4 | En-MS |
| T.1 | Tenant | Strategic definition | Have additional value from improved occupant satisfaction | I3.M1 | SM7 | HTM |

**Table 8.** User Stories for Strategic Definition for the Italian Pilot by DE5

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| BO.1 | Building Owner | Strategic definition | Evaluate which renewable energy technology is the most suitable to install in the building | I3.M1 | SM4 | iESD_E |
| BO.2 | Building Owner | Strategic definition | Evaluate which water treatment technology is most suitable to install in the building | I3.M2 | SM5 | iESD_W |
| BO.3 | Building Owner | Strategic definition | Obtain additional value from improved occupant satisfaction and energy efficiency | I3.M1 | SM7 | HTM |
| BO.4 | Building Owner | Strategic definition | Compliance with current building maintenance regulations, demanding a maintenance plan in the project | I4.M4 | SM1 | IMAN |
| BO.5 | Building Owners | Strategic definition | Identify the overarching objective and performance criteria | I2.M1 | SM1/SM2 | |
| BO.6 | Building Owners | Strategic definition | Strategy and target setting | I2.M1 | SM1/SM2 | Refurbify |
| PM.1 | Project Manager | Strategic definition | Set in the brief the environmental and/or circularity targets for a renovation or newbuild project | I2.M1 | SM2 | EPESUS |
| PM.2 | Project Manager | Strategic definition | To comply with the provisions of the building owner for the project design team (architects and engineers) | | | IMAN |
| CM.1 | Construction Manager | Strategic definition | Help to implement economic and environmental improvements to enhance competitiveness | I2.M1 | SM1/SM2 | CMT |

| | | | | | | |
|---|---|---|---|---|---|---|
| DT/BIM.1 | BIM / DT Manager | Strategic definition | Ensure that the BIM LOD level and DT software are compatible with the CMMS | I1.M4 | SM2 | CMT |
| C.1 | Contractor | Strategic definition | Deliver read-to-use input data for green building rating schemes to clients (DGNB, BREEAM, HQE and LEED) | I1.M3 | SM5 | CMT |
| A/D.1 | Architect /Designer | Strategic definition | Add value to buildings thanks to the quantification of environmental performance | | | CMT |
| A/D.1 | Architect /Designer | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I5.M2 | SM6 | En-MS |
| Eng.1 | Engineer | Strategic definition | Add value to buildings thanks to the quantification of environmental performance | | | CMT |
| MEP.1 | MEP Engineer | Strategic definition | Evaluate which renewable energy technology is the most suitable to install in the building | I3.M1 | SM5 | iESD_E |
| MEP.2 | MEP Engineer | Strategic definition | Determine the optimal sizing of renewable energy technologies based on the building conditions | I3.M1 | SM5 | iESD_E |
| MEP.3 | MEP Engineer | Strategic definition | Evaluate which water treatment technology is most suitable to install in the building | I3.M2 | SM5 | iESD_W |
| MEP.4 | MEP Engineer | Strategic definition | Determine the optimal sizing of water treatment technology based on the building conditions | I3.M2 | SM5 | iESD_W |
| MEP.5 | MEP Engineer | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I3.M2 | SM3/SM4 | En-MS |
| BA.1 | Build. Automation Team | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I3.M2 | SM3/SM4 | En-MS |
| T.1 | Tenant | Strategic definition | Have additional value from improved occupant satisfaction | I3.M2 | SM7 | HTM |

**Table 9.** User Stories for Strategic Definition for the Finnish pilot by VTT-Caverion

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| BO.1 | Building Owner | Strategic definition | Evaluate which renewable energy technology is the most suitable to install in the building | I3.M1 | SM4 | iESD_E |
| BO.2 | Building Owner | Strategic definition | Evaluate which water treatment technology is most suitable to install in the building | I3.M2 | SM5 | iESD_W |
| BO.3 | Building Owner | Strategic definition | Obtain additional value from improved occupant satisfaction and energy efficiency | I3.M1 | SM7 | HTM |
| BO.4 | Building Owner | Strategic definition | Compliance with current regulations on building maintenance, demand a maintenance plan in the project | I4.M4 | SM1 | IMAN |
| BO.5 | Building Owner | Strategy definition | Identify the overarching objective and performance criteria | I2.M1 | SM1/SM2 | TBD |
| PM.1 | Project Manager | Strategic definition | Set in the brief the environmental and/or circularity targets for a renovation or newbuild project | I2.M1 | SM2 | EPESUS |
| PM.2 | Project Manager | Strategic definition | To comply with the provisions of the building owner for the project design team (architects and engineers) | | | IMAN |
| CM.1 | Construction Manager | Strategic definition | Help to implement economic and environmental improvements to enhance competitiveness | I2.M1 | SM1/SM2 | CMT |
| DT/BIM.1 | BIM / DT Manager | Strategic definition | Ensure that the BIM LOD level and DT software are compatible with the CMMS | I1.M4 | SM2 | CMT |
| C.1 | Contractor | Strategic definition | Deliver read-to-use input data for green building rating schemes to clients (DGNB, BREEAM, HQE and LEED) | I1.M3 | SM5 | CMT |
| A/D.1 | Architect /Designer | Strategic definition | Add value to buildings thanks to the quantification of environmental performance | | | CMT |
| A/D.1 | Architect /Designer | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I5.M2 | SM4 | En-MS |
| Eng.1 | Engineer | Strategic definition | Add value to buildings thanks to the quantification of environmental performance | | | CMT |
| MEP.1 | MEP Engineer | Strategic definition | Evaluate which renewable energy technology is the most suitable to install in the building | I3.M1 | SM4 | iESD_E |
| MEP.2 | MEP Engineer | Strategic definition | Determine the optimal sizing of renewable energy technologies based on the building conditions | I3.M1 | SM4 | iESD_E |
| MEP.3 | MEP Engineer | Strategic definition | Evaluate which water treatment technology is most suitable to install in the building | I3.M2 | SM5 | iESD_W |
| MEP.4 | MEP Engineer | Strategic definition | Determine the optimal sizing of water treatment technology based on the building conditions | I3.M2 | SM5 | iESD_W |
| MEP.5 | MEP Engineer | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I5.M2 | SM4 | En-MS |
| BA.1 | Build. Automation Team | Strategic definition | Obtain information for energy improvement goals and targets in an energy renovation perspective | I5.M2 | SM4 | En-MS |
| T.1 | Tenant | Strategic definition | Have additional value from improved occupant satisfaction | I3.M1 | SM7 | HTM |
| | Caverion | Strategic definition | Strategy and target setting | I2.M1 | SM1 | |

**Table 10**. User Stories for Strategic Definition for the Netherlands pilot by TNO

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| PD.1 | Project Developer | Strategic definition | Strategy and target setting | I2.M2 | SM3 | No tools required, however, all project tools should use the same KPIs. |
| BO.2 | Building Owner | Strategic definition | Assess data needs for early understanding of outcome | I1.M3 | SM1 | No tools required, however, all project tools should use the same KPIs. |
| BO.3 | Building Owner | Strategic definition | Assess data needs for early understanding of outcome | I1.M3 | SM1 | No tools required, however, all project tools should use the same KPIs. |

## 5.2 Pilot and tool user stories for the Preparation & Brief

**Table 11.** User Stories for Preparation & Brief for the Austrian pilot by CREE

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| A.2 | Architect | Preparation & Brief | Receive an Environmental Product Declaration (EPD) for a building component | I3.M2 | SM1 | CMT |
| Eng.2 | Engineer | Preparation & Brief | Receive an Environmental Product Declaration (EPD) for a building component | I3.M2 | SM1 | CMT |
| MEP.6 | MEP Engineer | Preparation & Brief | Develop a quick model of a building and have a quick evaluation of the energy performance | I3.M1 | SM5 | ModSCO |
| S.1 | Surveyor | Preparation & Brief | Input previous relevant survey info into the correct document/asset location | I4.M2 | SM1 | Refurbify |
| S.2 | Surveyor | Preparation & Brief | Upload pre-condition surveys pertaining to the proposed retrofit/renovation | I1.M3 | SM1 | Refurbify |
| S.3 | Surveyor | Preparation & Brief | Upload relevant observed/collected information to the platform (walkover survey outcome) | I1.M3 | SM1 | FLINK2GO |
| Sc.1 | Const. sub-contractor | Preparation & Brief | Register my company via organisation framework, submit work-plans & costings prior to project start | | | Refurbify |
| PM.1 | Project Manager | Preparation & Brief | Use the SPHERE platform to calculate the project timescale, to set a critical path and track progress | I1.M2 | SM1/SM2 | Refurbify |
| PM.2 | Project Manager | Strategic definition | Add the project team and define their roles and responsibilities | I1.M1 | SM1/SM2 | FLINK2GO |
| PM.3 | Project Manager | Preparation & Brief | Start technical assessment and team formation | I2.M1 | SM2 | |
| PM.4 | Project Manager | Preparation & Brief | Assess need and listing of potential subcontractors and suppliers | I2.M1.SM1/I4.M2.SM1 | | |
| PM.5 | Project Manager | Preparation & Brief | Site Surveying - meeting | I2.M1.SM1/I4.M2.SM1 | | |
| PM.6 | Project Manager | Preparation & Brief | Basic cost estimation and report | | | |
| PM.7 | Project Manager | Preparation & Brief | Assessment of site survey, cost and targets (CREE, building owner) | | | |
| BO.1 | Building Owner | Preparation & Brief | Basic cost estimation and report | | | |
| DL.1 | Design Lead | Preparation & Brief | Early Concept Design Draft | I1.M1 | SM2 | |

**Table 12.** User Stories for Preparation & Brief for the Italian pilot by DE5

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Architect | Preparation & Brief | Receive an Environmental Product Declaration (EPD) for a building component | I3.M2 | SM1 | CMT |
| | Engineer | Preparation & Brief | Receive an Environmental Product Declaration (EPD) for a building component | I3.M2 | SM1 | CMT |
| | MEP Engineer | Preparation & Brief | Develop a quick model of a building and have a quick evaluation of the energy performance | I3.M1 | SM5 | ModSCO |
| | Surveyor | Preparation & Brief | Input previous relevant survey info into the correct document/asset location | I4.M2 | SM1 | Refurbify |
| | Surveyor | Preparation & Brief | Upload pre-condition surveys pertaining to the proposed retrofit/renovation | I1.M3 | SM1 | Refurbify |
| S.3 | Surveyor | Preparation & Brief | Upload relevant observed/collected information to the platform (walkover survey outcome) | I1.M3 | SM1 | FLINK2GO |
| PM.1 | Project Manager | Preparation & Brief | Use the SPHERE platform to calculate the project timescale, to set a critical path and track progress | I1.M2 | SM1/SM2 | Refurbify |
| PM.2 | Project Manager | Strategic definition | Add the project team and define their roles and responsibilities | I1.M1 | SM1/SM2 | FLINK2GO |
| | Const. sub-contractor | Preparation & Brief | Register my company via organisation framework, submit work-plans & costings prior to project start | | | Refurbify |
| PM.2 | Project Manager | Preparation & Brief | Start technical assessment and team formation | I2.M1 | SM2 | Refurbify, VCMP |
| PM.3 | Project Manager | Preparation & Brief | Assessment of site survey, cost and targets | | | |
| | Surveyor | Preparation & Brief | Site surveying and data collection for BIM | I2.M1.SM2/I4.M2.SM2 | | Refurbify, VCMP, Flink2go |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Surveyor | Preparation & Brief | Basic cost estimation and report | I4.M2 | | |

**Table 13.** User Stories for Preparation & Brief for the Finnish pilot by VTT-Caverion

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| A.2 | Architect | Preparation & Brief | Receive an Environmental Product Declaration (EPD) for a building component | I3.M2 | SM1 | CMT |
| Eng.2 | Engineer | Preparation & Brief | Receive an Environmental Product Declaration (EPD) for a building component | I3.M2 | SM1 | CMT |
| MEP.6 | MEP Engineer | Preparation & Brief | Develop a quick model of a building and have a quick evaluation of the energy performance | I3.M1 | SM5 | ModSCO |
| S.1 | Surveyor | Preparation & Brief | Input previous relevant survey info into the correct document/asset location | I4.M2 | SM1 | Refurbify |
| S.2 | Surveyor | Preparation & Brief | Upload pre-condition surveys pertaining to the proposed retrofit/renovation | I1.M3 | SM1 | Refurbify |
| S.3 | Surveyor | Preparation & Brief | Upload relevant observed/collected information to the platform (walkover survey outcome) | I1.M3 | SM1 | FLINK2GO |
| Sc.1 | Const. sub-contractor | Preparation & Brief | Register my company via organisation framework, submit work-plans & costing prior to project start | | | Refurbify |
| PM.1 | Project Manager | Preparation & Brief | Use the SPHERE platform to calculate the project timescale, to set a critical path and track progress | I1.M2 | SM1/SM 2 | Refurbify |
| PM.2 | Project Manager | Strategic definition | Add the project team and define their roles and responsibilities | I1.M1 | SM1/SM 2 | FLINK2GO |
| PM.2 | Project Manager | Preparation & Brief | Define participant roles and survey types | I2.M1 | SM2 | |
| PM.3 | Project Manager | Preparation & Brief | Surveying & Data Collection for BIM (existing building - partial BIM model) | | | |
| PM.4 | Project Manager | Preparation & Brief | Preliminary BIM use for thermal energy analysis (heating/cooling) for option selection) | I3.M1 | SM2 | |
| PM.5 | Project Manager | Preparation & Brief | Quantity take-off of materials / Bill of materials preparation | | | |
| PM.6 | Project Manager | Preparation & Brief | Cost Estimation Report building | | | |
| BO.1 | Building Owner | Preparation & Brief | Assessment of site survey, cost and targets | | | |

**Table 14.** User Stories for Preparation & Brief for the Netherlands pilot by TNO

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| PD.01 | Project developer | Strategic definition | Assess need and listing of potential subcontractors and suppliers | I2.M2 | SM2 | No tool required |

## 5.3 Pilot and tool user stories for the Concept and Technical Design

**Table 15**. User Stories for Concept Design for the Austrian Pilot by CREE

| US | As a | During | I want to | M | SM | Tools |
|---|---|---|---|---|---|---|
| | Building Owner | Concept Design | Preview the drawings, send feedback via the SPHERE platform | | | FLINK2GO |
| | Con. Manager | Concept Design | Cost-effective rating improvements for sustainability certification by achieving mix-design optimizations | | | CMT |
| | Con.Manager | Concept Design | Request product and application pricing information | I3.M2 | SM1 | OPT |
| | Architect/Designer | Concept Design | Make a quick calculation of environmental indicators and cost impacts for real-concrete mix-designs | I3.M2 | SM2 | CMT |
| | Architect/Designer | Concept Design | Download relevant component BIM objects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | Architect/Designer | Concept design | Structural checking of specific precast concrete elements such as façade panels | | | FRCT |
| | Architect/Designer | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | Architect/Designer | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | Architect/Designer | Concept Design | Carry out a preliminary evaluation of different design alternatives for the HVAC system | I3.M1 | SM4 | ECOSIMPRO |
| | Architect/Designer | Concept Design | Evaluate the environmental impact of my design using SPHERE and use this to inform the design choice | I3.M2 | SM2/SM4 | EPESUS |
| | Architect/Designer | Concept Design | Upload detailed iterations of the building drawings to the platform | I1.M3 | SM1 | FLINK2GO |
| | Architect/Designer | Concept Design | Receive feedback and identify any instructions required by the client/building owner | I5.M1 | SM3 | FLINK2GO |
| | Architect/Designer | Concept Design | Analyse the energy demand and expected indoor comfort as early as possible | I3.M1 | SM3 | ROBMOS |
| | Engineer | Concept design | Structural checking of specific precast concrete elements such as façade panels | | | FRCT |
| | Engineer | Concept Design | Make a quick calculation of environmental indicators and cost impacts for real-concrete mix-designs | I3.M2 | SM2 | CMT |
| | Engineer | Concept Design | Download relevant component BIM objects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | MEP Engineer | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | MEP Engineer | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | MEP Engineer | Concept Design | Generate an energy conservation opportunity by supporting design decision making | I5.M1 | SM2 | ModSCO |
| | MEP Engineer | Concept Design | Investigate HVAC related energy demand, based on my elected installations | I3.M1 | SM3 | ROBMOS |
| | BIM Manager | Concept Design | Receive BIM models to be implemented in the BIM Building Design | I1.M4 | SM2 | FRCT |
| | BIM / DT Manager | Concept Design | Ensure project designers include in project DDBB all information/requirements for good maintenance | | | IMAN |
| | Contractor | Concept Design | Download relevant component BIM objects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | Build. Facility Manager | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | Build. Facility Manager | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | Build. Automation Team | Concept Design | Obtain additional value by offering a new sophisticated control solution | I3.M1 | SM7 | HTM |
| | Design Lead | Concept Design | Concept design project management activities | I2.M1 | SM2 | |
| | Design Lead | Concept Design | Concept design based on BIM | I2.M1 | SM2 | |
| | Design Team | Concept Design | Concept design based on BIM | I2.M1 | SM2 | |
| | Design Lead | Concept Design | Data collection from building physics Civil Engineers/MEP subcontractor (Meetings + Data Input ) | I2.M.1 | SM2 | |
| | Site Manager | Concept Design | Data collection from building physics Civil Engineers/MEP subcontractor (Meetings + Data Input ) | I2.M.1 | SM2 | |
| | Design Lead | Concept Design | Design size Iteration (sizing columns, components, windows) | I1.M4 | SM2 | |
| | Design Team | Concept Design | Design size Iteration (sizing columns, components, windows) | I1.M4 | SM2 | |

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|---|---|---|---|---|---|---|
| | Design Expert | Concept Design | Preliminary Simulations | I3.M1 | SM4 | |
| | Design Expert | Concept Design | Life cycle assessment (LCA) | I3.M2 | SM2 | |
| | Project Manager | Concept Design | Contacting specialist for concept design | I1.M4 | SM1 | |
| | Design Lead | Concept Design | Contacting specialist for concept design | I1.M4 | SM1 | |
| | Project Manager | Concept Design | Early materials quantities/mass / BoQ - Cost analysis | | | |
| | Design Lead | Concept Design | Early materials quantities/mass / BoQ - Cost analysis | | | |
| | All Roles/IDDS | Concept Design | Concept Design Workshop (Design Team, Project Lead, Building Owner, CREE) | I2.M.1 | SM2 | |
| | Design Lead | Concept Design | Revision and finalising of the concept design | I4.M1 | SM.1 | |

**Table 16**. User Stories for Concept Design for the Italian Pilot by DE5

| US | As a | During | I want to | M | SM | Tools |
|---|---|---|---|---|---|---|
| | Building Owner | Concept Design | Preview the drawings, send feedback via the SPHERE platform | I1.M3 | SM4 | FLINK2GO |
| | Construction Manager | Concept Design | Cost-effective rating improvements in the sustainability certification by achieving mix-design optimizations | | | CMT |
| | Construction Manager | Concept Design | Request product and application pricing information | I3.M2 | SM1 | OPT |
| | Architect/Designer | Concept Design | Make a quick calculation of environmental indicators and cost impacts for real-concrete mix-designs | I3.M2 | SM2 | CMT |
| | Architect/Designer | Concept Design | Download relevant component BIM objects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | Architect/Designer | Concept design | Structural checking of specific precast concrete elements such as façade panels | | | FRCT |
| | Architect/Designer | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | Architect/Designer | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | Architect/Designer | Concept Design | Carry out a preliminary evaluation of different design alternatives for the HVAC system | I3.M1 | SM4 | ECOSIMPRO |
| | Architect/Designer | Concept Design | Evaluate the environmental impact of my design using SPHERE and use this to inform the design choice | I3.M2 | SM2/SM4 | EPESUS |
| | Architect/Designer | Concept Design | Upload detailed iterations of the building drawings to the platform | I1.M3 | SM1 | FLINK2GO |
| | Architect/Designer | Concept Design | Receive feedback and identify any instructions required by the client/building owner | I5.M1 | SM3 | FLINK2GO |
| | Architect/Designer | Concept Design | Analyse the energy demand and expected indoor comfort as early as possible | I3.M1 | SM3 | ROBMOS |
| | Engineer | Concept design | Structural checking of specific precast concrete elements such as façade panels | | | FRCT |
| | Engineer | Concept Design | Make a quick calculation of environmental indicators and cost impacts for real-concrete mix-designs | I3.M2 | SM2 | CMT |
| | Engineer | Concept Design | Download relevant component BIM objects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | MEP Engineer | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | MEP Engineer | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | MEP Engineer | Concept Design | Generate an energy conservation opportunity by supporting design decision making | I5.M1 | SM2 | ModSCO |
| | MEP Engineer | Concept Design | Investigate HVAC related energy demand, based on my elected installations | I3.M1 | SM3 | ROBMOS |
| | BIM Manager | Concept Design | Receive BIM models to be implemented in the BIM Building Design | I1.M4 | SM2 | FRCT |
| | BIM / DT Manager | Concept Design | Ensure that project designers include in project DDBB all information/requirements for good maintenance | | | IMAN |
| | Contractor | Concept Design | Download relevant component BIM objects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | Build. Facility Manager | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | Build. Facility Manager | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |

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|---|---|---|---|---|---|---|
| | Build. Autom. Team | Concept Design | Obtain additional value by offering a new sophisticated control solution | I3.M1 | SM7 | HTM |
| | Project Manager | Concept Design | Concept design project management activities | I2.M1/I3.M1 | SM2/SM2 | Refubify, VCMP |
| | Design Team | Concept Design | Concept design based on BIM | I2.M1 | SM2 | |
| | Design Team | Concept Design | Preliminary Simulations | I3.M1 | SM1 | ECOSIM/HTM/ CLARITY |
| | Design Team | Concept Design | Early materials quantities/mass / BoQ - Cost analysis | | | |
| | All Roles/IDDS | Concept Design | Concept Design Workshop | I2.M.1 | SM.2 | Refurbify |
| | Design Team | Concept Design | Revision and finalising of the concept design | I4.M.3/I4.M4 I3.M1 | SM.3/SM1 All | ECOSIMPRO/MODS CO/HTM/CLARITY |

**Table 17.** User Stories for Concept Design for the Finnish pilot by VTT-Caverion

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Building Owner | Concept Design | Preview the drawings, send feedback via the SPHERE platform | I1.M3 | SM4 | FLINK2GO |
| | Const. Manager | Concept Design | Make cost-effective rating improvements in the sustainability certification by achieving mix-design optimizations | | | CMT |
| | Const. Manager | Concept Design | Request product and application pricing information | I3.M2 | SM1 | OPT |
| | Architect/Designer | Concept Design | Make a quick calculation of environmental indicators and cost impacts for real-concrete mix-designs | I3.M2 | SM2 | CMT |
| | Architect/Designer | Concept Design | Download the relevant BIM objects of components directly without the need to surf through several databases | I1.M4 | SM2 | OPT |
| | Architect/Designer | Concept design | Structural checking of specific precast concrete elements such as façade panels | | | FRCT |
| | Architect/Designer | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | Architect/Designer | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | Architect/Designer | Concept Design | Carry out a preliminary evaluation of different design alternatives for the HVAC system | I3.M1 | SM4 | ECOSIMPRO |
| | Architect/Designer | Concept Design | Evaluate the environmental impact of my design using SPHERE and use this to inform the design choice | I3.M2 | SM2/SM4 | EPESUS |
| | Architect/Designer | Concept Design | Analyse the energy demand and expected indoor comfort as early as possible | I3.M1 | SM3 | ROBMOS |
| | Architect/Designer | Concept Design | Upload detailed iterations of the building drawings to the platform | I1.M3 | SM1 | FLINK2GO |
| | Architect/Designer | Concept Design | Receive feedback and identify any instructions required by the client/building owner | I5.M1 | SM3 | FLINK2GO |
| | Engineer | Concept design | Structural checking of specific precast concrete elements such as façade panels | | | FRCT |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Engineer | Concept Design | Make a quick calculation of environmental indicators and cost impacts for real-concrete mix-designs | I3.M2 | SM2 | CMT |
| | Engineer | Concept Design | Download the relevant BIM objects of components directly without the need to surf through several databases | I1.M4 | SM2 | OPT |
| | MEP Engineer | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | MEP Engineer | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | MEP Engineer | Concept Design | Generate an energy conservation opportunity by supporting design decision making | I5.M1 | SM2 | ModSCO |
| | MEP Engineer | Concept Design | Investigate HVAC related energy demand, based on my elected installations | I3.M1 | SM3 | ROBMOS |
| | BIM Manager | Concept Design | Receive BIM models to be implemented in the BIM Building Design | I1.M4 | SM2 | FRCT |
| | BIM / DT Manager | Concept Design | Ensure that project designers include in project DDBB all information/requirements for good maintenance | | | IMAN |
| | Contractor | Concept Design | Download the relevant BIM objects of components directly without the need to surf through several databases | I1.M4 | SM2 | OPT |
| | Build. Facility Manager | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM4 | iESD_E |
| | Build. Facility Manager | Concept Design | Calculate and evaluate water availability (grey and rainwater) and water requirements of the building | I3.M2 | SM5 | iESD_W |
| | Build. Autom.Team | Concept Design | Obtain additional value by offering a new sophisticated control solution | I3.M1 | SM7 | HTM |
| | Project Lead | Concept Design | Concept design project management activities | I2.M1 | SM2 | |
| | Caverion | Concept Design | BIM Data Collection | | | |
| | Caverion | Concept Design | BIM Modeling using the survey data | I5.M2 | SM4 | |
| | Design Team | Concept Design | Detailed Simulations (Energy/Daylight/Ventilation) to assess system and performance for chosen option | I5.M2 | SM4 | |
| | Design Team | Concept Design | Concept Design | I5.M2 | SM2 | |
| | All Roles/IDDS | Concept Design | Concept Design Workshop | I5.M2 | SM2 | |
| | Caverion | Concept Design | Cost Analysis | | | |
| | Design Team | Concept Design | Revision and finalising of the concept design | | | |

**Table 18**. User Stories for Concept Design for the Netherlands Pilot by TNO

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Design Expert | Concept Design | Calculate and evaluate the energy requirements of the building (heating, cooling, DHW and lighting) | I3.M1 | SM2 | ROBMOS/IEQ |
| | Design Lead | Concept Design | Carry out a preliminary evaluation of different design alternatives for the HVAC system | I3.M1 | SM2 | ROBMOS/IEQ |
| | MEP Engineer | Concept Design | Investigate HVAC related energy demand, based on my elected installations | I3.M1 | SM3 | ROBMOS/IEQ |

**Table 19**. User Stories for Developed and Technical Design for the Austrian Pilot by CREE

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Precast Producer | Dev. & Tech Design | Optimize my production processes and create a database for corporate sustainability | I3.M2 | SM1 | CMT |
| | Contractor | Dev. & Tech Design | Assess the improvement potential of concrete in buildings | | | CMT |
| | Architect/Designer | Dev. & Tech Design | Understand the potential and implication of using innovative concrete solutions in structures | I3.M2 | SM2 | CMT |
| | Architect/Designer | Dev. & Tech Design | Study potential passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4 | iESD_E |
| | Architect/Designer | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM5 | iESD_W |
| | Architect/Designer | Dev. & Tech Design | Evaluate different design alternatives for the HVAC System | I3.M1 | SM4 | ECOSIMPRO |
| | Architect/Designer | Dev. & Tech Design | Basic guidelines to implement HTM control (spacedata monitoring/occupant data/BAS integration) | I3.M1 | SM7 | HTM |
| | Architect/Designer | Dev. & Tech Design | Evaluate the environmental impact of my design using SPHERE and log my “As Designed” Performance | | | EPESUS |
| | Architect/Designer | Dev. & Tech Design | Upload detailed iterations of the building drawings to the platform | I5.M1 | SM3 | FLINK2GO |
| | Architect/Designer | Dev. & Tech Design | Receive feedback and identify any instructions required by the client/building owner | I3.M2 | SM2 | FLINK2GO |
| | Engineer | Dev. & Tech Design | Understand the potential and implication of using innovative concrete solutions in structures | I3.M2 | SM2 | CMT |
| | MEP Engineer | Dev. & Tech Design | Study potential passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | MEP Engineer | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | MEP Engineer | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | MEP Engineer | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M2 | SM7 | iESD_W |
| | Maint Service company | Dev. & Tech Design | Download relevant component BIMobjects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | Building Owner | Dev. & Tech Design | Preview the drawings, send feedback via the SPHERE platform | I1.M3 | SM4 | FLINK2GO |
| | Building Owner | Dev. & Tech Design | Study potential passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | Building Owner | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | Building Owner | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | Building Owner | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M2 | SM7 | iESD_W |
| | Build. Facility Manager | Dev. & Tech Design | Study potential passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | Build. Facility Manager | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | Build. Facility Manager | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | Build. Facility Manager | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M1 | SM5 | iESD_W |
| | Build. Automation Team | Dev. & Tech Design | Analyse HVAC Control Strategies and their building performance impacts | I3.M1 | SM4/SM5 | ECOSIMPRO |
| | Build. Automation Team | Dev. & Tech Design | Definitions for data transfer and APIs (e.g. reading space-data/occupant experiences/writing set-points) | I3.M1 | SM7 | HTM |
| | BIM / DT Manager | Dev. & Tech Design | Ensure that project designers include in DDBB all information/requirements for good maintenance | | | IMAN |

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|---|---|---|---|---|---|---|
| | Digital Twin Conf. Man. | Dev. & Tech Design | Configure different design alternatives of the HVAC system for comparison purposes | I3.M1 | SM4/SM5 | ECOSIMPRO |
| | Design Lead | Dev. & Tech Design | Developed & Technical Design preparation | I2.M1 | SM.2 | |
| | Design Team | Dev. & Tech Design | Developed & Technical Design Design based on BIM | I3.M3 | SM1 | |
| | Design Team | Dev. & Tech Design | Simulations (Energy, daylight, ventilation simulations) | I3.M1. | SM5 | |
| | Design Team | Dev. & Tech Design | Life cycle assessment (LCA) | I3.M2 | SM2 | |
| | Project Manager | Dev. & Tech Design | Contacting subcontractors and suppliers - quotes for technical design | | | |
| | Building Owner | Dev. & Tech Design | Contacting subcontractors and suppliers - quotes for technical design | | | |
| | Design Lead | Dev. & Tech Design | Final Material quantities/mass/BoQ - Cost analysis | | | |
| | Design Team | Dev. & Tech Design | Final Material quantities/mass/BoQ - Cost analysis | | | |
| | Project Manager | Dev. & Tech Design | Design Workshops | I2.M1 | SM.2 | |
| | Design Team | Dev. & Tech Design | Design Workshops | I2.M1 | SM.2 | |
| | Building Owner | Dev. & Tech Design | Design Workshops | I2.M1 | SM.2 | |
| | Design Lead | Dev. & Tech Design | Revision and finalising of the dev. & tech. designs and optimisation of the prefabrication components | I4.M4 | SM1 | |
| | Design Team | Dev. & Tech Design | Revision and finalising of the dev. & tech. designs and optimisation of the prefabrication components | I4.M4 | SM1 | |

**Table 20.** User Stories for Developed and Technical Design for the Italian pilot by DE5

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Precast producer | Dev. & Tech Design | Optimize my production processes and create a database for corporate sustainability | I3.M2 | SM1 | CMT |
| | Contractor | Dev. & Tech Design | Assess the improvement potential of concrete in buildings | | | CMT |
| | Architect/Designer | Dev. & Tech Design | Understand the potential and implication of using innovative concrete solutions in structures | I3.M2 | SM2 | CMT |
| | Architect/Designer | Dev. & Tech Design | Study passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4 | iESD_E |
| | Architect/Designer | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM5 | iESD_W |
| | Architect/Designer | Dev. & Tech Design | Evaluate different design alternatives for the HVAC System | I3.M1 | SM4 | ECOSIMPRO |
| | Architect/Designer | Dev. & Tech Design | Basic guidelines to implement HTM control (spacedata monitoring/occupant data/BAS integration) | I3.M1 | SM7 | HTM |
| | Architect/Designer | Dev. & Tech Design | Evaluate the environmental impact of my design using SPHERE and log my “As Designed” Performance | | | EPESUS |
| | Architect/Designer | Dev. & Tech Design | Upload detailed iterations of the building drawings to the platform | I5.M1 | SM3 | FLINK2GO |
| | Architect/Designer | Dev. & Tech Design | Receive feedback and identify any instructions required by the client/building owner | I3.M2 | SM2 | FLINK2GO |
| | Engineer | Dev. & Tech Design | Understand the potential and implication of using innovative concrete solutions in structures | I3.M2 | SM2 | CMT |
| | MEP Engineer | Dev. & Tech Design | Study passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | MEP Engineer | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | MEP Engineer | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | MEP Engineer | Dev. & Tech Design | Determine the most efficient equipment for building installation given water demand profiles | I3.M2 | SM7 | iESD_W |
| | Maint Service company | Dev. & Tech Design | Download relevant component BIMobjects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | Building Owner | Dev. & Tech Design | Preview the drawings, send feedback via the SPHERE platform | I1.M3 | SM4 | FLINK2GO |
| | Building Owner | Dev. & Tech Design | Study passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | Building Owner | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | Building Owner | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | Building Owner | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M2 | SM7 | iESD_W |

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|---|---|---|---|---|---|---|
| | Build. Facility Manager | Dev. & Tech Design | Study passive+active solutions for building installation & analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | Build. Facility Manager | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | Build. Facility Manager | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | Build. Facility Manager | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M1 | SM5 | iESD_W |
| | Build. Automation Team | Dev. & Tech Design | Analyse HVAC Control Strategies and their building performance impacts | I3.M1 | SM4/SM5 | ECOSIMPRO |
| | Build. Automation Team | Dev. & Tech Design | Definitions for data transfer & APIs (e.g. reading space data/occupant experiences/writing set-points) | I3.M1 | SM7 | HTM |
| | BIM / DT Manager | Dev. & Tech Design | Ensure project designers include in project DDBB all information/requirements for good maintenance | | | IMAN |
| | Digital Twin Conf. Man. | Dev. & Tech Design | Configure different design alternatives of the HVAC system for comparison purposes | I3.M1 | SM4/SM5 | ECOSIMPRO |
| | Project Manager | Dev. & Tech Design | Developed & Technical Design preparation | I3.M3 | SM.1 | Refurbify,VCMP |
| | Design Team | Dev. & Tech Design | Developed & Technical Design based on BIM | I3.M3 | SM.1 | Clarity |
| | Design Team | Dev. & Tech Design | Simulations | I3.M.1 | SM.3 | ECOSIMPRO/HTM/CLARITY |
| | Design Team | Dev. & Tech Design | Life cycle assessment (LCA) | I3.M2 | SM2 | OPT/EPESUS |
| | Design Team | Dev. & Tech Design | Life Cycle Cost (LCC) Analysis | I3.M2 | SM3 | OPT/EPESUS |
| | Design Team | Dev. & Tech Design | Final Material quantities/mass/BoQ - Cost analysis | I2.M.1 | SM.2 | |
| | All Roles/IDDS | Dev. & Tech Design | Design Workshops | I2.M.1 | SM.2 | Refurbify |
| | Design Team | Dev. & Tech Design | Revision and finalising of the dev. & tech. designs and optimisation of the prefabrication components | I3.M.2 | SM.1 | ECOMSIMPRO/ModSCO/HTM/EPESUS/CLARITY |

**Table 21**. User Stories for Developed and Technical Design for the Finnish pilot by VTT-Caverion

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Precast producer | Dev. & Tech Design | Optimize my production processes and create a database for corporate sustainability | I3.M2 | SM1 | CMT |
| | Contractor | Dev. & Tech Design | Assess the improvement potential of concrete in buildings | | | CMT |
| | Architect/Designer | Dev. & Tech Design | Understand the potential and implication of using innovative concrete solutions in structures | I3.M2 | SM2 | CMT |
| | Architect/Designer | Dev. & Tech Design | Study potential passive+active solutions for building installation and analyse impacts (energy/cost/env.) | I3.M1 | SM4 | iESD_E |
| | Architect/Designer | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM5 | iESD_W |
| | Architect/Designer | Dev. & Tech Design | Evaluate different design alternatives for the HVAC System | I3.M1 | SM4 | ECOSIMPRO |
| | Architect/Designer | Dev. & Tech Design | Have basic guidelines to implement HTM control (spacedata monitoring/occupant data/BAS integration) | I3.M1 | SM7 | HTM |
| | Architect/Designer | Dev. & Tech Design | Upload detailed iterations of the building drawings to the platform | I1.M3 | SM1 | FLINK2GO |
| | Architect/Designer | Dev. & Tech Design | Receive feedback and identify any instructions required by the client/building owner | I5.M1 | SM3 | FLINK2GO |
| | Architect/Designer | Dev. & Tech Design | Evaluate the environmental impact of my design using SPHERE and log my “As Designed” Performance | I3.M2 | SM2 | EPESUS |
| | Engineer | Dev. & Tech Design | Understand the potential and implication of using innovative concrete solutions in structures | I3.M2 | SM2 | CMT |
| | MEP Engineer | Dev. & Tech Design | Study passive+active solutions for installation in the building and analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | MEP Engineer | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | MEP Engineer | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | MEP Engineer | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M2 | SM7 | iESD_W |
| | Maint Service Company | Dev. & Tech Design | Download the relevant BIM objects of components directly without the need to surf through several databases | I1.M4 | SM2 | OPT |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Building Owner | Dev. & Tech Design | Preview the drawings, send feedback via the SPHERE platform | I1.M3 | SM4 | FLINK2GO |
| | Building Owner | Dev. & Tech Design | Study passive+active solutions for installation in the building and analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | Building Owner | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | Building Owner | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | Building Owner | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M2 | SM7 | iESD_W |
| | Build. Facility Manager | Dev. & Tech Design | Study passive+active solutions for installation in the building and analyse impacts (energy/cost/env.) | I3.M1 | SM4/SM5 | iESD_E |
| | Build. Facility Manager | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on demand profiles | I3.M1 | SM5 | iESD_E |
| | Build. Facility Manager | Dev. & Tech Design | Evaluate suitable water treatment technologies in terms of water, costs and sustainability | I3.M2 | SM7 | iESD_W |
| | Build. Facility Manager | Dev. & Tech Design | Determine the most efficient equipment to be installed in the building based on water demand profiles | I3.M1 | SM5 | iESD_W |
| | Build. Automation Team | Dev. & Tech Design | Analyse HVAC Control Strategies and their building performance impacts | I3.M1 | SM4/SM5 | ECOSIMPRO |
| | Build. Automation Team | Dev. & Tech Design | Definitions for data transfer & APIs (e.g. reading space data/occupant experiences/writing set-points) | I3.M1 | SM7 | HTM |
| | BIM / DT Manager | Dev. & Tech Design | Ensure project designers include in project DDBB all information/requirements for good maintenance | | | IMAN |
| | Digital Twin Conf. Man. | Dev. & Tech Design | Configure different design alternatives of the HVAC system for comparison purposes | I3.M1 | SM4/SM5 | ECOSIMPRO |
| | Project Lead | Dev. & Tech Design | Update project execution plan | I4.M2 | SM4 | |

**Table 22.** User Stories for Developed and Technical Design for the Netherlands Pilot by TNO

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Architect/Designer | Dev. & Tech Design | Study potential passive + active solutions for building installation and analyse impacts (energy/cost/env.) | I3.M1 | SM4 | ROBMOS, IEQ, ECOSIMPRO |
| | Architect/Designer | Dev. & Tech Design | Evaluate different design alternatives for the HVAC System | I3.M1 | SM4 | ROBMOS, IEQ, ECOSIMPRO |
| | Design Expert | Concept Design | Simulations | I3.M1 | SM1 | ROBMOS,ECOSIMPRO, IEQ |
| | Design Lead | Concept Design | Revision and finalising developed & technical designs and optimisation of prefabrication components | I3.M1 | SM2 | ROBMOS,IEQ |
| | Build. Automation Team | Dev. & Tech Design | Analyse HVAC Control Strategies and their building performance impacts | I3.M1 | SM4/SM5 | ROBMOS,IEQ |
| | Digital Twin Conf. Man. | Dev. & Tech Design | Configure different design alternatives of the HVAC system for comparison purposes | I3.M1 | SM4/SM5 | ROBMOS,IEQ |

## 5.4. Pilot and tool user stories for Tendering

**Table 23.** User Stories for Tendering (Italy)

| | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| 20 | Building Owner | Tendering | Tendering for project manager and construction manager | I1.M5 | SM1 | Refurbify&Clarity |
| 21 | Construction Manager | Tendering | Tendering for construction team formation | I1.M5 | SM1 | Refurbify&Clarity |
| 22 | Construction Manager | Tendering | Tendering brief preparation | I1.M5 | SM1 | Refurbify&Clarity |
| 23 | Construction Manager | Tendering | Tendering documents collection from multiple bidders | I1.M5 | SM1 | Refurbify&Clarity,VCMP |
| 24 | Construction Manager | Tendering | Tendering bid review & acceptance | I1.M5 | SM1 | Refurbify&Clarity |
| 25 | Construction Manager | Tendering | Contract Agreement | I1.M5 | SM1,SM2 | Refurbify&Clarity |

## 5.5. Pilot and tool user stories for the Construction and Assembly

**Table 24**. User Stories for Construction and Assembly or Renovation for the Austrian Pilot by CREE

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Concrete Producer | Const./Renovation | Provide transparency and optimize the environmental footprint of concrete versus costs | I3.M2 | SM2/SM3 | CMT |
| | Concrete Producer | Const./Renovation | Answer the customer's requests for the life cycle data on concrete | I3.M2 | SM2 | CMT |
| | Cons. Lead | Const./Renovation | Create tasks/issues, scheduling, assigning to internal/external responsible and mark location in building 2D drawing | I4.M2 | SM1 | FLINK2GO |
| | Cons. Lead | Const./Renovation | Initiate approval directly on the SPHERE platform to report/validate the subcontractors work | I4.M1 | SM1 | FLINK2GO |
| | Const. Manager | Const./Renovation | Download the relevant BIM objects of components directly without the need to surf through several databases | I1.M4 | SM2 | OPT |
| | Const. Manager | Const./Renovation | Obtain an EPD for construction product(s) that I want to use in my project to comply with requirements | I2.M1 | SM3 | TBD |
| | Const. Manager | Const./Renovation | Manage my construction process and schedule my tasks against a project plan | I1.M2 | SM1/SM2 | Refurbify |
| | Const. Manager | Const./Renovation | Calculate the costs and benefits of total or partial steel reinforcement replacements in façade panels & slabs | I3.M2 | SM3 | FRCT |
| | Const. Manager | Const./Renovation | Gather all information on preventive and predictive maintenance operations for proper maintenance | I5.M1 | SM4 | IMAN |
| | Const. Manager | Const./Renovation | Demand maintenance information gathering from subcontractors and suppliers of equipment/materials | I5.M1 | SM4 | IMAN |
| | Const. Manager | Const./Renovation | Handover maintenance information to person in charge of the IMAN | I4.M6 | SM1 | IMAN |
| | Contractor | Const./Renovation | Compare different solutions for my projects based on BIM objects and pricing information. | I1.M4 | SM2/SM3 | OPT |
| | Contractor | Const./Renovation | Request product and application pricing information | I1.M4 | SM2/SM3 | OPT |
| | Contractor | Const./Renovation | Calculate the costs and benefits of total or partial steel reinforcement replacements in façade panels & slabs | | | FRCT |
| | Contractor | Const./Renovation | Upload certificates/qualifications for my employees/allowing them access to particular job-types | | | Refurbify |
| | Certification Cons. | Const./Renovation | Obtain information about resource efficiency, CO2 performance, water use, materials and waste | I3.M2 | SM2 | EPESUS |
| | Project Manager | Const./Renovation | Have an overview on the overall project status for monitoring purposes. (Delayed tasks, urgent issues) | I4.M2 | SM4 | FLINK2GO |
| | Surveyor | Const./Renovation | Initiate detailed site surveys focusing on specific issues | I4.M2 | SM2 | FLINK2GO |
| | Surveyor | Const./Renovation | Save all the obtained information of the survey on the platform and shared among the concerned parties | I4.M2 | SM2 | FLINK2GO |
| | Surveyor | Const./Renovation | Effectively plan my survey activities and use the SPHERE platform to schedule my tasks | I4.M2 | SM1 | Refurbify |
| | Project Manager | Const./Renovation | Construction Project Management | I2.M1.SM2/I4.M1.SM3/I4.M2.SM1 | | |
| | Construction Lead | Const./Renovation | Construction Project Management | I2.M1.SM2/I4.M1.SM3/I4.M2.SM1 | | |
| | Subcontractors | Const./Renovation | Construction Project Management | I2.M1.SM2/I4.M1.SM3/I4.M2.SM1 | | |
| | Construction Lead | Const./Renovation | Prefabrication Manufacturing | | | |
| | Subcontractors | Const./Renovation | Prefabrication Manufacturing | | | |
| | Construction Lead | Const./Renovation | Construction of foundation and core of the building (reinforced concrete core) | I4.M2 (SM1,2,3), I4.M3 (SM1,2), I4.M1.SM1) | | |
| | Subcontractors | Const./Renovation | Construction of foundation and core of the building (reinforced concrete core) | I4.M2 (SM1,2,3), I4.M3 (SM1,2), I4.M1.SM1) | | |
| | Construction Lead | Const./Renovation | Prefabrication Delivery to the site (by subcontractors + suppliers) | I4.M2/I4.M3 | SM1,SM4/SM2 | |
| | Subcontractors | Const./Renovation | Prefabrication Delivery to the site (by subcontractors + suppliers) | I4.M2/I4.M3 | SM1,SM4/SM2 | |
| | Construction Lead | Const./Renovation | Assembly of the hybrid prefabricated elements (by subcontractors + suppliers) | I4.M2 (SM1,2,3), I4.M3 (SM1,2,3), I4.M1.SM1) | | |
| | Subcontractors | Const./Renovation | Assembly of the hybrid prefabricated elements (by subcontractors + suppliers) | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | IDDS | Const./Renovation | Continuous Status Monitoring and Reporting (Construction Lead, subcontractors + suppliers) | I4.M2/I4.M2/I4.M1/ SM/SM1,3/SM1 | | |
| | Build. Autom. Team | Const./Renovation | Commissioning & Building automation installation (by subcontractors + suppliers) | I4.M2/I4.M3/I4.M5 | SM1,SM4/SM1/SM 1 | |
| | Subcontractors | Const./Renovation | Commissioning & Building automation installation (by subcontractors + suppliers) | I4.M2/I4.M3/I4.M5 | SM1,SM4/SM1/SM 1 | |
| | Suppliers | Const./Renovation | Commissioning & Building automation installation (by subcontractors + suppliers) | I4.M2/I4.M3/I4.M5 | SM1,SM4/SM1/SM 1 | |

**Table 25**. User Stories for Construction and Assembly or Renovation for the Italian Pilot by DE5

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Concrete Producer | Const./Renovation | Provide transparency and optimize the environmental footprint of concrete versus costs | I3.M2 | SM2/SM3 | CMT |
| | Concrete producer | Const./Renovation | Answer the customer's requests for the life cycle data on concrete | I3.M2 | SM2 | CMT |
| | Cons. Lead | Const./Renovation | Create tasks/issues, scheduling, assigning to internal/external responsible and mark location in building 2D drawing | I4.M2 | SM1 | FLINK2GO |
| | Cons. Lead | Const./Renovation | Initiate approval directly on the SPHERE platform to report/validate the subcontractors work | I4.M1 | SM1 | FLINK2GO |
| | Construction Manager | Const./Renovation | Download relevant BIM objects of components directly without the need to surf through several databases | I1.M4 | SM2 | OPT |
| | Construction Manager | Const./Renovation | Obtain an EPD for construction product(s) that I want to use in my project to comply with requirements | I2.M1 | SM3 | EPESUS |
| | Construction Manager | Const./Renovation | Manage my construction process and schedule my tasks against a project plan | I1.M2 | SM1/SM2 | Refurbify |
| | Construction Manager | Const./Renovation | Calculate the costs and benefits of total or partial steel reinforcement replacements in façade panels & slabs | I3.M2 | SM3 | FRCT |
| | Construction Manager | Const./Renovation | Gather all information on preventive and predictive maintenance operations for proper maintenance | I5.M1 | SM4 | IMAN |
| | Construction Manager | Const./Renovation | Demand maintenance information gathering from subcontractors and suppliers of equipment/materials | I5.M1 | SM4 | IMAN |
| | Construction Manager | Const./Renovation | Handover maintenance information to person in charge of the IMAN | I4.M6 | SM1 | IMAN |
| | Contractor | Const./Renovation | Compare different solutions for my projects based on BIM objects and pricing information | I1.M4 | SM2/SM3 | OPT |
| | Contractor | Const./Renovation | Request product and application pricing information | I1.M4 | SM2/SM3 | OPT |
| | Contractor | Const./Renovation | Calculate the costs and benefits of total or partial steel reinforcement replacements in façade panels & slabs | | | FRCT |
| | Contractor | Const./Renovation | Upload certificates/qualifications for my employees/allowing them access to particular job-types | | | Refurbify |
| | Certification Consult. | Const./Renovation | Obtain information about resource efficiency, CO2 performance, water use, materials and waste | I3.M2 | SM2 | EPESUS |
| | Project Manager | Const./Renovation | Have an overview on the overall status of the project for the monitoring purposes. (Delayed tasks, urgent issues) | I4.M2 | SM4 | FLINK2GO |
| | Surveyor | Const./Renovation | Initiate detailed site surveys focusing on specific issues | I4.M2 | SM2 | FLINK2GO |
| | Surveyor | Const./Renovation | Save all the obtained information of the survey on the platform and shared among the concerned parties | I4.M2 | SM2 | FLINK2GO |
| | Surveyor | Const./Renovation | Effectively plan my survey activities and use the SPHERE platform to schedule my tasks | I4.M2 | SM1 | Refurbify |
| | Construction Manager | Const./Renovation | Construction Project Management | I4.M.1 | SM.3 | Refurbify, VCMP |
| | General Contractor | Const./Renovation | Start work and provisioning of construction materials | I4.M.2 | SM.1 | Refurbify, VCMP |
| | General Contractor | Const./Renovation | Site preparation and provisional works | I4.M.3 | SM.2 | Refurbify, VCMP, FLINK2GO |
| | General Contractor | Const./Renovation | Construction of foundation and core structural | I4.M.2 | SM.2 | |
| | General Contractor | Const./Renovation | General construction work (wall, plaster and windows) | I4.M.1 | SM.3 | |
| | General Contractor | Const./Renovation | MEP and implant installations | I4.M.2 | SM.4 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | General Contractor | Const./Renovation | Finishing (flooring, paint and doors) | I4.M.2 | SM.4 | |
| | IDDS | Const./Renovation | Continuous Status Monitoring and Reporting (managed by construction manager) | I4.M.2 | SM.4 | |
| | Commissioning Team | Const./Renovation | Commissioning & Building automation installation | I1.M.3 | SM.2 | Refurbify, VCMP, CLARITY |

**Table 26**. User Stories for Construction and Assembly or Renovation for the Finnish pilot by VTT-Caverion

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Concrete Producer | Const./Renovation | Provide transparency and optimize the environmental footprint of concrete versus costs | I3.M2 | SM2/SM3 | CMT |
| | Concrete producer | Const./Renovation | Answer the customer's requests for the life cycle data on concrete | I3.M2 | SM2 | CMT |
| | Cons. Lead | Const./Renovation | Create tasks/issues, scheduling, assigning to internal/external responsible and mark location in building 2D drawing | I4.M2 | SM1 | FLINK2GO |
| | Cons. Lead | Const./Renovation | Initiate approval directly on the SPHERE platform to report/validate the subcontractors work | I4.M1 | SM1 | FLINK2GO |
| | Const. Manager | Const./Renovation | Download relevant component BIM objects directly without needing to surf through several databases | I1.M4 | SM2 | OPT |
| | Const. Manager | Const./Renovation | Obtain an EPD for construction product(s) that I want to use in my project to comply with requirements | I2.M1 | SM3 | TBD |
| | Const. Manager | Const./Renovation | Manage my construction process and schedule my tasks against a project plan | I1.M2 | SM1/SM2 | Refurbify |
| | Const. Manager | Const./Renovation | Calculate costs and benefits of total or partial steel reinforcement replacements in façade panels & slabs | I3.M2 | SM3 | FRCT |
| | Const. Manager | Const./Renovation | Gather all information on preventive and predictive maintenance operations for proper maintenance | I5.M1 | SM4 | IMAN |
| | Const. Manager | Const./Renovation | Demand maintenance information gathering from subcontractors and suppliers of equipment/materials | I5.M1 | SM4 | IMAN |
| | Const. Manager | Const./Renovation | Handover maintenance information to person in charge of the IMAN | I4.M6 | SM1 | IMAN |
| | Contractor | Const./Renovation | Compare different solutions for my projects based on BIM objects and pricing information | I1.M4 | SM2/SM3 | OPT |
| | Contractor | Const./Renovation | Request product and application pricing information | I1.M4 | SM2/SM3 | OPT |
| | Contractor | Const./Renovation | Calculate costs and benefits of total or partial steel reinforcement replacements in façade panels & slabs | | | FRCT |
| | Contractor | Const./Renovation | Upload certificates/qualifications for my employees/allowing them access to particular job-types | | | Refurbify |
| | Certification cons. | Const./Renovation | Obtain information about resource efficiency, CO2 performance, water use, materials and waste | I3.M2 | SM2 | EPESUS |
| | Project Manager | Const./Renovation | Have an overview on the overall status of the project for the monitoring purposes. (Delayed tasks, urgent issues) | I4.M2 | SM4 | FLINK2GO |
| | Surveyor | Const./Renovation | Initiate detailed site surveys focusing on specific issues | I4.M2 | SM2 | FLINK2GO |
| | Surveyor | Const./Renovation | Save all the obtained information of the survey on the platform and shared among the concerned parties | I4.M2 | SM2 | FLINK2GO |
| | Surveyor | Const./Renovation | Effectively plan my survey activities and use the SPHERE platform to schedule my tasks | I4.M2 | SM1 | Refurbify |
| | Construction Lead | Const./Renovation | Scheduling of the Renovation Works | I4.M2 | SM1 | |
| | Caverion | Const./Renovation | Communication of the Renovation with the Housing Occupants | | | |
| | Caverion | Const./Renovation | Renovation Implementation & Building Automation Installation | | | |
| | All Roles/IDDS | Const./Renovation | Continuous Status Monitoring and Reporting | I4.M2 | SM4 | |
| | Commissioning Team | Const./Renovation | Commissioning | I4.M5 | SM1 | |

**Table 27**. User Stories for Construction and Assembly or Renovation for the Netherlands Pilot by TNO

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Construction lead | Const./Renovation | Manage my construction process and schedule my tasks against a project plan | I1.M2 | SM1/SM2 | Refurbify |
| | Surveyor | Const./Renovation | Effectively plan my survey activities and use the SPHERE platform to schedule my tasks | I4.M2 | SM1 | Refurbify |
| | Construction Lead | Construction & Assembly | Prefabrication Manufacturing | I4.M2 | SM2 | Refurbify |
| | Building Automation Team | Construction & Assembly | Commissioning & Building automation installation | I4.M5 | SM1 | Refurbify |
| | Subcontractors | Construction & Assembly | Commissioning & Building automation installation | I I4.M3 | SM1 | Refurbify |
| | Suppliers | Construction & Assembly | Commissioning & Building automation installation | I4.M2 | SM2 | Refurbify |

## 5.6 Pilot and tool user stories for the Handover & Close-Out Phase

**Table 28.** User Stories for Handover and Close Out for the Austrian Pilot by CREE

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Automation Team | Hand. & Close-out | Speed up commissioning and detect problems in advance | I4.M5 | SM1 | ECOSIMPRO, RobMOS |
| | Build. Automation Team | Hand. & Close-out | Conduct field test period and analyse results (occupant satisfaction and energy consumption | I5.M2 | SM5 | HTM |
| | Maint. Service Company | Hand. & Close-out | Assess services against required standards prior to and post commissioning | I4.M4 | SM1 | Clarity |
| | Build. Facility Manager | Hand. & Close-out | Analyse building services data to ensure commissioning has been carried out correctly | I4.M5 | SM1 | Clarity |
| | Build. Facility Manager | Hand. & Close-out | Dialogue with BIM platform to use DT simulation tool to optimise energy operating costs of building | I5.M2 | SM3 | IMAN/ModSCO/ECOSIMPRO |
| | Surveyor | Hand. & Close-out | Carry out handover surveys & submit results for approval. Access re-works jobs & submit for handover | I4.M6 | SM1 | VCMP |
| | Project Manager | Hand. & Close-out | Utilise the document management facility to store and retrieve project documents | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | Hand. & Close-out | Submit completed works for handover. | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | Hand. & Close-out | View failed handover details and re-submit following remedial works | I4.M6 | SM1 | VCMP |
| | Project Manager | Hand. & Close-out | Undertake the tasks listed in the Handover Strategy | I4.M2.SM4/I4.M6.SM1 | | VCMP |
| | Build. Automation Team | Hand. & Close-out | Undertake the tasks listed in the Handover Strategy | I4.M2.SM4/I4.M6.SM1 | | Clarity |
| | Build. Automation Team | Hand. & Close-out | Manage updating of As Built Information and review progress and performance of construction | I4.M1.SM1/I4.M6.SM1 | | VCMP |
| | Building Owner | Hand. & Close-out | Manage updating of As Built Information and review progress and performance of construction | I4.M1.SM1/I4.M6.SM1 | | VCMP |
| | Design Team | Hand. & Close-out | Manage updating of As Built Information and review progress and performance of construction | I4.M1.SM1/I4.M6.SM1 | | VCMP |

**Table 29**. User Stories for Handover and Close Out for the Italian Pilot by DE5

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Automation Team | Hand. & Close-out | Speed up commissioning and detect problems in advance | I4.M5 | SM1 | ECOSIMPRO |
| | Build. Automation Team | Hand. & Close-out | Conduct field test period and analyse results (occupant satisfaction and energy consumption | I5.M2 | SM5 | HTM |
| | Maint. Service Company | Hand. & Close-out | Assess services against required standards prior to and post commissioning | I4.M4 | SM1 | Clarity |
| | Build. Facility Manager | Hand. & Close-out | Analyse building services data to ensure commissioning has been carried out correctly | I4.M5 | SM1 | Clarity |
| | Build. Facility Manager | Hand. & Close-out | Dialogue with BIM platform to use DT simulation tool to optimise energy operating costs of building | I5.M2 | SM3 | IMAN |
| | Surveyor | Hand. & Close-out | Carry out handover surveys & submit results for approval. Access re-works jobs & submit for handover | I4.M6 | SM1 | VCMP |
| | Project Manager | Hand. & Close-out | Utilise the document management facility to store and retrieve project documents | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | Hand. & Close-out | Submit completed works for handover. | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | Hand. & Close-out | View failed handover details and re-submit following remedial works | I4.M6 | SM1 | VCMP |
| | Construction Manager | Hand. & Close-out | Undertake the tasks listed in the Handover Strategy | I4.M1.SM1/I4.M2.SM4 | | |
| | IDDS | Hand. & Close-out | Manage updating of As Built Information and review progress and performance of construction | I4.M3.SM1/I4.M6.SM1 | | |

**Table 30.** User Stories for Handover and Close Out for the Finnish pilot by VTT-Caverion

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Automation Team | Handover & Close-out | Speed up commissioning and detect problems in advance | I4.M5 | SM1 | Ecosimpro |
| | Build. Automation Team | Handover & Close-out | Conduct field test period and analyse results (occupant satisfaction and energy consumption | I5.M2 | SM5 | HTM |
| | Maint. Service Company | Handover & Close-out | Assess services against required standards prior to and post commissioning | I4.M4 | SM1 | Clarity |
| | Build. Facility Nanager | Handover & Close-out | Analyse building services data to ensure commissioning has been carried out correctly | I4.M5 | SM1 | Clarity |
| | Build. Facility Manager | Handover & Close-out | Dialogue with BIM platform to use DT simulation tool to optimise energy operating costs of building | I5.M2 | SM3 | CMMS |
| | Surveyor | Handover & Close-out | Carry out handover surveys & submit the results for approval. Access re-works jobs and submit for handover | I4.M6 | SM1 | VCMP |
| | Project Manager | Handover & Close-out | Utilise the document management facility to store and retrieve project documents | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | Handover & Close-out | Submit completed works for handover. | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | Handover & Close-out | View failed handover details and re-submit following remedial works | I4.M6 | SM1 | VCMP |
| | Construction Manager | Handover & Close-Out | Undertake the tasks listed in the Handover Strategy | I4.M6 | SM1 | |
| | IDDS | Handover & Close-Out | Manage updating of As Built Information and review progress and performance of construction | I4.M3 | SM1 | |

**Table 31**. User Stories for Handover and Close Out for the Dutch Pilot by TNO

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Automation Team | Construction & Assembly | Continuous monitoring and reporting | I5.M2 | SM1 | RobMOS,IEQ (reporting) |
| | Build. Facility Manager | Construction & Assembly | Continuous monitoring and reporting | I5.M2 | SM4 | ROBMOS,IEQ (reporting) |

## 5.7 Pilot and tool user stories for the In Use Phase

**Table 32.** User Stories for In Use Phase for the Austrian pilot by CREE

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Facility Manager | In Use | See the baseline energy operation and evaluate alternatives | I5.M2 | SM3 | ECOSIMPRO |
| | Build. Facility Manager | In Use | Have new remote management capabilities and additional value from improved occupant satisfaction/energy eff. | I5.M2 | SM5,SM6 | EN-MS/HTM |
| | Build. Facility Manager | In Use | Understand how well my building is performing environmentally relative to “As designed & As built” expectations | I4.M3 | SM1 | EPESUS |
| | Build. Facility Manager | In Use | Optimize the HVAC setting by comparing real data with the baseline model (generated by the ROM) | I5.M2 | SM3 | ModSCO |
| | Build. Facility Manager | In Use | Obtain information to define a maintenance strategy | I5.M2 | SM6 | En-MS |
| | Build. Facility Manager | In Use | Obtain information for monitoring, managing & optimizing efficiency, energy consumption and occupant comfort | I5.M2 | SM6 | En-MS |
| | Build. Facility Manager | In Use | Create alerts for system downtime/interruption to connectivity | I5.M2 | SM1 | Clarity |
| | Build. Facility Manager | In Use | Manage building issues created by the tenants and assign them to the responsible Maintenance Service Company | I5.M1 | SM3 | FLINK2GO |
| | Build. Facility Manager | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS |
| | Maint Service Company | In Use | Compare the baseline energy operation with measured variables to detect problems | I5.M2 | SM3 | ECOSIMPRO |
| | Maint Service Company | In Use | Correct the operation of HVAC systems | I5.M2 | SM3 | ModSCO |
| | Maint Service Company | In Use | Consult daily/weekly performance reports and monitor energy conservation opportunities | I5.M2 | SM3 | ModSCO |
| | Maint Service Company | In Use | Obtain information to define a maintenance strategy | I5.M1 | SM1 | En-MS |
| | Maint Service Company | In Use | Obtain information for monitoring, managing and optimizing the efficiency of building systems | I5.M2 | SM1 | En-MS |
| | Maint Service Company | In Use | Access reports to investigate downtime to services | I5.M2 | SM1 | Clarity |
| | Maint Service Company | In Use | Ensure that IMAN contains the necessary information for all the units of work subject to maintenance | I5.M1 | SM1 | IMAN |
| | Maint Service Company | In Use | Ensure that IMAN is linked to all necessary sensors are installed to detect a future fault and for predictive actions | I5.M1 | SM3 | IMAN |
| | Maint Service Company | In Use | Ensure that the IMAN is compatible with the simulation tools of the DT platform to improve operations | I5.M2 | SM1 | IMAN |
| | Maint Service Company | In Use | Investigate if my installations need service, or investigate the cause of the energy and comfort performance gap | I5.M2 | SM3 | RobMOS |
| | BIM Manager | In Use | Use the SPHERE platform to visualise my device locations | I5.M2 | SM2 | Clarity |
| | BIM Manager | In Use | Access live or near-live data relating to a building element or BIM object | I5.M2 | SM1 | Clarity |
| | Digital Twin Sim. Man. | In Use | Decide on different operation alternatives related to the HVAC system for comparison | I5.M2 | SM3 | ECOSIMPRO |
| | Building Owner | In Use | Receive automated reports of realized occupant’s thermal satisfaction and energy efficiency | I5.M2 | SM5 | HTM |
| | Building Owner | In Use | Investigate if the real energy demand of the building is in line with the predicted energy demand | I5.M2 | SM3 | RobMOS |
| | Build. Automation Team | In Use | Receive valid information about functionality of HTM technology to update Building Automation Systems | I5.M2 | SM5 | HTM |
| | Tenant | In Use | Have additional value from improved occupant satisfaction | I5.M2 | SM5 | HTM |
| | Tenant | In Use | Report issues to the Building Facility Manager | I5.M1 | SM4 | FLINK2GO |
| | Tenant | In Use | Obtain information for optimizing efficiency, energy consumption and occupant comfort | I5.M2 | SM6 | En-MS |
| | Contractor | In Use | Adjust to changing project requirements and receive crucial product-in-use information for project-planning steps | | | |
| | Constr. Sub-contractor | In Use | Submit completed works for handover | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | In Use | View failed handover details and re-submit following remedial works | I4.M6 | SM1 | VCMP |
| | Architect/Designer | In Use | Receive valid information about functionality of HTM technology to improve design guidelines | I5.M2 | SM5 | HTM |
| | Certification Consult. | In Use | Analyse the ideal (generated by ROM) vs actual performance of a building following M&V protocols | I5.M2 | SM3/SM6 | ModSCO |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Surveyor | In Use | Receive alerts or notifications when surveys are due or overdue | I5.M2 | SM7 | VCMP |
| | Surveyor | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS |
| | Project Manager | In Use | Track the progress of my retrofit works. | I5.M1 | SM.2 | VCMP |
| | Project Manager | In Use | Identify and schedule works | I5.M1 | SM.1 | VCMP |
| | Building Owner | In Use | Takeover and deliver to occupants | I4.M.6 | SM.1 | |
| | Building Owner | In Use | Continuous monitoring and reporting | I5.M.2 | SM.1 | |
| | Facility Manager | In Use | Continuous monitoring and reporting | I5.M.2 | SM.1 | |
| | Maint. Service Company | In Use | Reactionary and Planned Maintenance | I5.M.1 | SM.1 | |

**Table 33.** User Stories for In Use Phase for the Italian Pilot by DE5

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Facility Manager | In Use | See the baseline energy operation and evaluate alternatives | I5.M2 | SM3 | ECOSIMPRO |
| | Build. Facility Manager | In Use | Have new remote management capabilities & additional value from improved occupant satisfaction/energy eff. | I5.M2 | SM5,SM6 | HTM |
| | Build. Facility Manager | In Use | Understand how well my building is performing environmentally relative to “As designed & As built” expectations | I4.M3 | SM1 | EPESUS |
| | Build. Facility Manager | In Use | Optimize the HVAC setting by comparing real data with the baseline model (generated by the ROM) | I5.M2 | SM3 | ModSCO |
| | Build. Facility Manager | In Use | Obtain information to define a maintenance strategy | I5.M2 | SM6 | En-MS |
| | Build. Facility Manager | In Use | Obtain information for monitoring, managing and optimizing efficiency, energy consumption and occupant comfort | I5.M2 | SM6 | En-MS |
| | Build. Facility Manager | In Use | Create alerts for system downtime/interruption to connectivity | I5.M2 | SM1 | Clarity |
| | Build. Facility Manager | In Use | Manage building issues created by the tenants and assign them to the responsible Maintenance Service Company | I5.M1 | SM3 | FLINK2GO |
| | Build. Facility Manager | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS |
| | Maint Service Company | In Use | Compare the baseline energy operation with measured variables to detect problems | I5.M2 | SM3 | ECOSIMPRO |
| | Maint Service Company | In Use | Correct the operation of HVAC systems | I5.M2 | SM3 | ModSCO |
| | Maint Service Company | In Use | Consult daily/weekly performance reports and monitor energy conservation opportunities | I5.M2 | SM3 | ModSCO |
| | Maint Service Company | In Use | Obtain information to define a maintenance strategy | I5.M1 | SM1 | En-MS |
| | Maint Service Company | In Use | Obtain information for monitoring, managing and optimizing the efficiency of building systems | I5.M2 | SM1 | En-MS |
| | Maint Service Company | In Use | Access reports to investigate downtime to services | I5.M2 | SM1 | Clarity |
| | Maint Service Company | In Use | Ensure that IMAN contains the necessary information for all the units of work subject to maintenance | I5.M1 | SM1 | IMAN |
| | Maint Service Company | In Use | Ensure that IMAN is linked to all necessary sensors are installed to detect a future fault and for predictive actions | I5.M1 | SM3 | IMAN |
| | Maint Service Company | In Use | Ensure that the IMAN is compatible with the simulation tools of the DT platform to improve operations | I5.M2 | SM1 | IMAN |
| | Maint Service Company | In Use | Investigate if my installations need service, or investigate the cause of energy and comfort performance gap | I5.M2 | SM3 | RobMOS |
| | BIM Manager | In Use | Use the SPHERE platform to visualise my device locations | I5.M2 | SM2 | Clarity |
| | BIM Manager | In Use | Access live or near-live data relating to a building element or BIM object | I5.M2 | SM1 | Clarity |
| | Digital Twin Sim. Man. | In Use | Decide on different operation alternatives related to the HVAC system for comparison | I5.M2 | SM3 | ECOSIMPRO |
| | Building Owner | In Use | Receive automated reports of realized occupant’s thermal satisfaction and energy efficiency | I5.M2 | SM5 | HTM |
| | Building Owner | In Use | Investigate if the real energy demand of the building is in line with the predicted energy demand | I5.M2 | SM3 | RobMOS |
| | Build. Automation Team | In Use | Receive valid information about functionality of HTM technology to update Building Automation Systems | I5.M2 | SM5 | HTM |
| | Tenant | In Use | Have additional value from improved occupant satisfaction | I5.M2 | SM5 | HTM |
| | Tenant | In Use | Report issues to the Building Facility Manager | I5.M1 | SM4 | FLINK2GO |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Tenant | In Use | Obtain information for optimizing efficiency, energy consumption and occupant comfort | I5.M2 | SM6 | En-MS |
| | Contractor | In Use | Adjust to changing project requirements and receive crucial product-in-use information for project-planning steps | | | |
| | Constr. Sub-contractor | In Use | Submit completed works for handover | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | In Use | View failed handover details and re-submit following remedial works | I4.M6 | SM1 | VCMP |
| | Architect/Designer | In Use | Receive valid information about functionality of HTM technology to improve design guidelines | I5.M2 | SM5 | HTM |
| | Certification Consult. | In Use | Analyse the ideal (generated by ROM) vs actual performance of a building following M&V protocols | I5.M2 | SM3/SM6 | ModSCO |
| | Surveyor | In Use | Receive alerts or notifications when surveys are due or overdue | I5.M2 | SM7 | VCMP |
| | Surveyor | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS |
| | Project Manager | In Use | Track the progress of my retrofit works. | I5.M1 | SM.2 | VCMP |
| | Project Manager | In Use | Identify and schedule works | I5.M1 | SM.1 | VCMP |
| | Building Owner | In Use | Takeover and deliver to occupants | I4.M6 | SM.1 | Refurbify, VCMP |
| | Building Owner | In Use | Continuous monitoring and reporting | I5.M2 | SM.1 | HTM, RobMOS,Clarity, Refurbify, En-MS, MANI |
| | Facility Manager | In Use | Continuous monitoring and reporting | I5.M2 | SM.1 | |
| | Maint. Service Company | In Use | Reactionary and Planned Maintenance | I5.M1 | SM.1 | Refurbify, MANI, VCMP |

**Table 34**. User Stories for In Use Phase for the Finnish pilot by VTT-Caverion

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Facility Manager | In Use | See the baseline energy operation and evaluate alternatives | I5.M2 | SM3 | ECOSIMPRO |
| | Build. Facility Manager | In Use | Have new remote management capabilities and additional value from improved occupant satisfaction/energy eff. | I5.M2 | SM5,SM6 | EN-MS/HTM |
| | Build. Facility Manager | In Use | Understand how well my building is performing environmentally relative to “As designed & As built” expectations | I4.M3 | SM1 | TBD |
| | Build. Facility Manager | In Use | Optimize the HVAC setting by comparing real data with the baseline model (generated by the ROM) | I5.M2 | SM3 | ModSCO |
| | Build. Facility Manager | In Use | Obtain information to define a maintenance strategy | I5.M2 | SM6 | En-MS |
| | Build. Facility Manager | In Use | Obtain information for monitoring, managing & optimizing efficiency, energy consumption and occupant comfort | I5.M2 | SM6 | En-MS |
| | Build. Facility Manager | In Use | Create alerts for system downtime/interruption to connectivity | I5.M2 | SM1 | Clarity |
| | Build. Facility Manager | In Use | Manage building issues created by the tenants and assign them to the responsible Maintenance Service Company | I5.M1 | SM3 | FLINK2GO |
| | Build. Facility Manager | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS |
| | Maint Service Company | In Use | Compare the baseline energy operation with measured variables to detect problems | I5.M2 | SM3 | ECOSIMPRO |
| | Maint Service Company | In Use | Correct the operation of HVAC systems | I5.M2 | SM3 | ModSCO |
| | Maint Service Company | In Use | Consult daily/weekly performance reports and monitor energy conservation opportunities | I5.M2 | SM3 | ModSCO |
| | Maint Service Company | In Use | Obtain information to define a maintenance strategy | I5.M1 | SM1 | En-MS |
| | Maint Service Company | In Use | Obtain information for monitoring, managing and optimizing the efficiency of building systems | I5.M2 | SM1 | En-MS |
| | Maint Service Company | In Use | Access reports to investigate downtime to services | I5.M2 | SM1 | Clarity |
| | Maint Service Company | In Use | Ensure that IMAN contains the necessary information for all the units of work subject to maintenance | I5.M1 | SM1 | IMAN |
| | Maint Service Company | In Use | Ensure that IMAN is linked to all necessary sensors are installed to detect a future fault and for predictive actions | I5.M1 | SM3 | IMAN |
| | Maint Service Company | In Use | Ensure that the IMAN is compatible with the simulation tools of the DT platform to improve operations | I5.M2 | SM1 | IMAN |
| | Maint Service Company | In Use | Investigate if my installations need service, or investigate the cause of the energy and comfort performance gap | I5.M2 | SM3 | RobMOS |
| | BIM Manager | In Use | Use the SPHERE platform to visualise my device locations | I5.M2 | SM2 | Clarity |
| | BIM Manager | In Use | Access live or near-live data relating to a building element or BIM object | I5.M2 | SM1 | Clarity |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Digital Twin Sim. Man. | In Use | Decide on different operation alternatives related to the HVAC system for comparison | I5.M2 | SM3 | ECOSIMPRO |
| | Building Owner | In Use | Receive automated reports of realized occupant's thermal satisfaction and energy efficiency | I5.M2 | SM5 | HTM |
| | Building Owner | In Use | Investigate if the real energy demand of the building is in line with the predicted energy demand | I5.M2 | SM3 | RobMOS |
| | Build. Automation Team | In Use | Receive valid information about functionality of HTM technology to update Building Automation Systems | I5.M2 | SM5 | HTM |
| | Tenant | In Use | Have additional value from improved occupant satisfaction | I5.M2 | SM5 | HTM |
| | Tenant | In Use | Report issues to the Building Facility Manager | I5.M1 | SM4 | FLINK2GO |
| | Tenant | In Use | Obtain information for optimizing efficiency, energy consumption and occupant comfort | I5.M2 | SM6 | En-MS |
| | Contractor | In Use | Adjust to changing project requirements and receive crucial product-in-use information for project-planning steps | | | |
| | Constr. Sub-contractor | In Use | Submit completed works for handover | I4.M6 | SM1 | VCMP |
| | Constr. Sub-contractor | In Use | View failed handover details and re-submit following remedial works | I4.M6 | SM1 | VCMP |
| | Architect/Designer | In Use | Receive valid information about functionality of HTM technology to improve design guidelines | I5.M2 | SM5 | HTM |
| | Certification Consult. | In Use | Analyse the ideal (generated by ROM) vs actual performance of a building following M&V protocols | I5.M2 | SM3/SM6 | ModSCO |
| | Surveyor | In Use | Receive alerts or notifications when surveys are due or overdue | I5.M2 | SM7 | VCMP |
| | Surveyor | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS |
| | Project Manager | In Use | Track the progress of my retrofit works. | I5.M1 | SM.2 | VCMP |
| | Project Manager | In Use | Identify and schedule works | I5.M1 | SM.1 | VCMP |
| | Building Owner | In Use | Deliver to building owner and service company that operates the building | | | |
| | Building Automation | In Use | Continuous monitoring and reporting | | | |
| | Caverion | In Use | Update the digital data during the in-use phase | | | |
| | Maint. Service Company | In Use | Reactionary and Planned Maintenance | I5.M1 | SM3 | |

**Table 35**. User Stories for In Use Phase for the Netherlands Pilot by TNO

| US | As a | During | I want to | M | SM | Tool |
|---|---|---|---|---|---|---|
| | Build. Facility Manager | In Use | See the baseline energy operation and evaluate alternatives | I5.M2 | SM3 | ROBMOS,IEQ |
| | Build. Facility Manager | In Use | Optimize the HVAC setting by comparing real data with the baseline model (generated by the ROM) | I5.M2 | SM3 | ROBMOS,IEQ |
| | Build. Facility Manager | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS,IEQ |
| | Maint Service Company | In Use | Consult daily/weekly performance reports and monitor energy conservation opportunities | I5.M2 | SM3 | ROBMOS,IEQ |
| | Maint Service Company | In Use | Investigate if my installations need service, or investigate the cause of the energy and comfort performance gap | I5.M2 | SM3 | RobMOS,IEQ |
| | Building Owner | In Use | Investigate if the real energy demand of the building is in line with the predicted energy demand | I5.M2 | SM3 | RobMOS,IEQ |
| | Surveyor | In Use | Investigate causes of the energy performance gap between digital twin and real building | I5.M2 | SM3 | RobMOS,IEQ |

# 6 SPHERE Platform Information Flow Requirements

The delivered user stories and features described by four pilot partners (DE5, CAV, CREE, TNO) for Austria, Italy, Finland and Netherlands, were utilised to create a concise overview of the sequence of activities and information flow diagrams in these pilots based on the platforms. Together they form a set of required functionality needs in sequence for the piloting, as a start of developing a pilot implementation plan. The diagrams document both the actors involved, the activity, and the information flows (inputs and outputs) that form a basis for describing also the data flows from/to the platform in the technical architecture definitions in work-package 3.

## 6.1 Activity & Information Flow Process Diagrams For the Austrian Pilot

**Figure 7.** Austrian Pilot Strategic Definition Phase Activity & Information Flow Process Diagram

**1. Strategic definition**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Brief & target data/documents | Strategy and target setting | Brief template<br>Strategic brief export | to be able to identify the overarching objective and performance criteria of the project | CREE | - Data integration, data standardisation and access to the data (for the authorised actors).<br>- Brief template export & sharing options.<br>- Basic project information and requirements/targets stored as a standard form.<br>- Assessment of Digital Twin scope/configuration. |
| B | Brief & target data/documents | Assess data needs for early understanding of outcomes | Findings report | to identify the survey needs | Collaborative (IDDS) | - Data sharing across multiple actors.<br>- Basic project information and requirements/targets stored as a standard form.<br>- Assessment of Digital Twin data needs. |

**Figure 8.** Austrian Pilot Preparation and Brief Phase Activity & Information Flow Process Diagram

## 2. Preparation and brief

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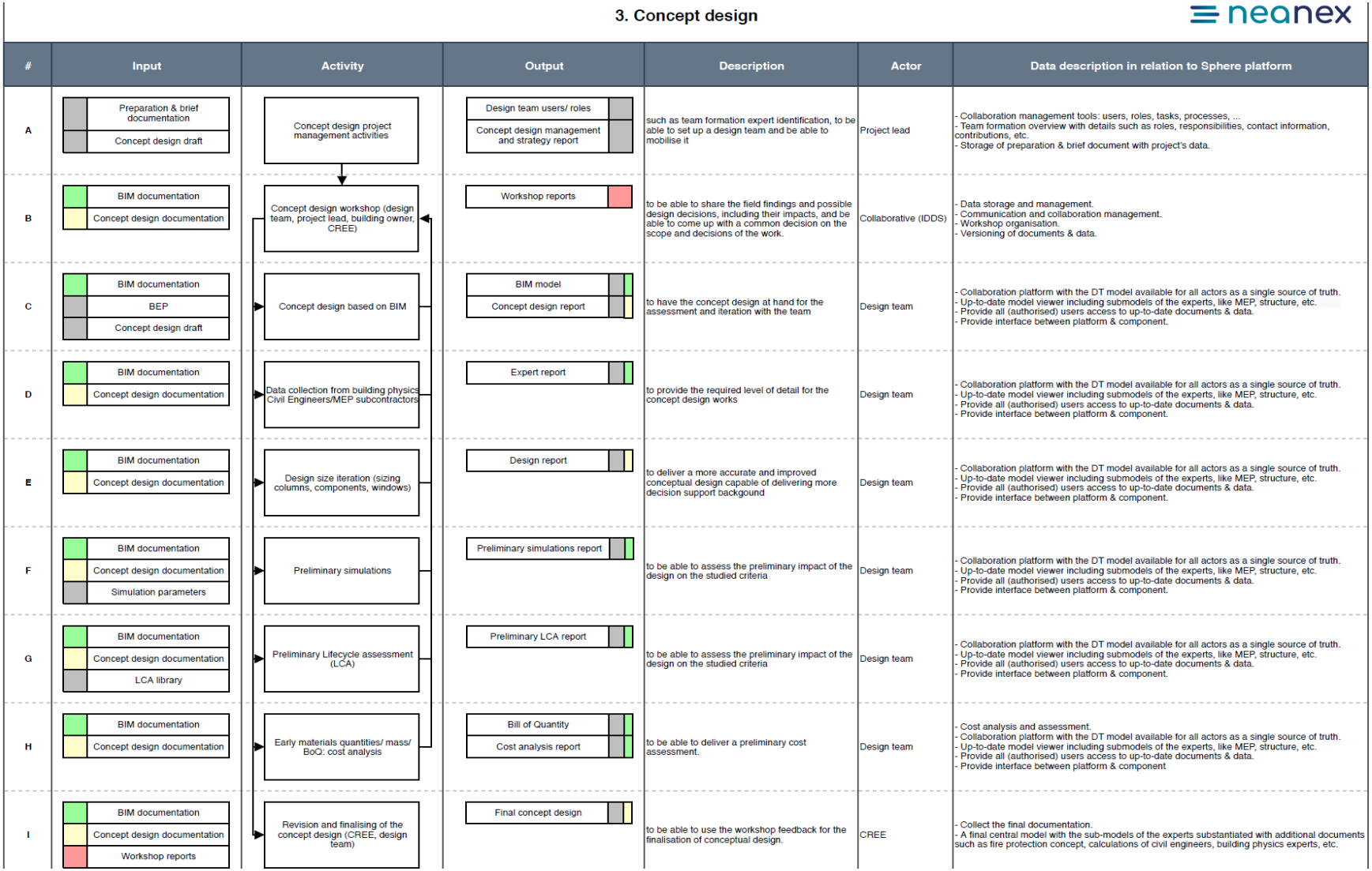
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Brief & target data/ documents | Start technical assessment and team formation | Team formation (users & roles)<br>Phases & processes<br>Survey needs | to assign and mobilise team. | Project lead | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- Storage of technical assessment information (type of construction system or software used).<br>- Storage of brief & target setting data, including the survey data. |
| B | Previous findings<br>Survey needs | Site surveying - meeting | Meeting agenda<br>Team formation (users & roles)<br>Survey data | to have an initial field assessment and identify/ share responsibilities | Surveyors | - Meeting agenda<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- The survey data should be integrated through a common data type. |
| C | Survey data<br>Brief & target data/ documents | Early concept design draft | Target setting<br>BIM Execution Plan (BEP)<br>Concept design draft | to be able to assess the scope of works | CREE | - Definition of requirements & needs.<br>- BIM Execution Plan as a document, available for all (authorised) users.<br>- Concept design report: a document with all the requirements and needs from the owner, like number of flats, size, number of rooms, levels, etc. |
| D | Concept design draft<br>Survey data | Assessment of site survey, cost and targets (CREE, building owner) | Site survey, concept design and targets report | to be able to collect correct information from site and hire / mobilise the related professionals for the work | Collaborative (IDDS) | - Team formation tools: users, roles, tasks, processes, ...<br>- Access to survey data and concept design draft for all (authorised) users. |

**Figure 9.** Austrian Pilot Concept Design Phase Activity & Information Flow Process Diagram



### 3. Concept design

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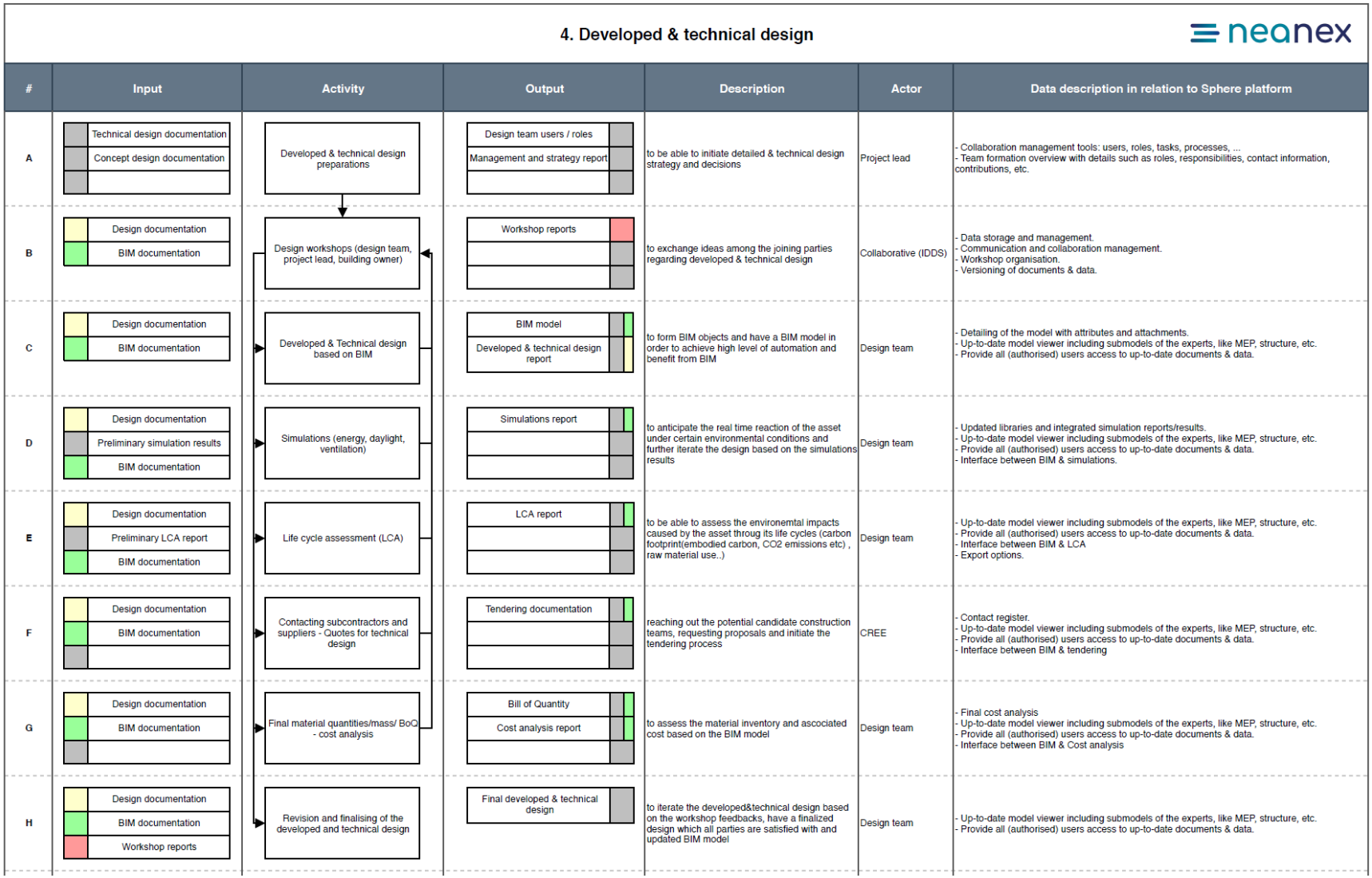
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Preparation & brief documentation<br>Concept design draft | Concept design project management activities | Design team users/ roles<br>Concept design management and strategy report | such as team formation expert identification, to be able to set up a design team and be able to mobilise it | Project lead | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- Storage of preparation & brief document with project's data. |
| B | BIM documentation<br>Concept design documentation | Concept design workshop (design team, project lead, building owner, CREE) | Workshop reports | to be able to share the field findings and possible design decisions, including their impacts, and be able to come up with a common decision on the scope and decisions of the work. | Collaborative (IDDS) | - Data storage and management.<br>- Communication and collaboration management.<br>- Workshop organisation.<br>- Versioning of documents & data. |
| C | BIM documentation<br>BEP<br>Concept design draft | Concept design based on BIM | BIM model<br>Concept design report | to have the concept design at hand for the assessment and iteration with the team | Design team | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Provide interface between platform & component. |
| D | BIM documentation<br>Concept design documentation | Data collection from building physics Civil Engineers/MEP subcontractors | Expert report | to provide the required level of detail for the concept design works | Design team | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Provide interface between platform & component. |
| E | BIM documentation<br>Concept design documentation | Design size iteration (sizing columns, components, windows) | Design report | to deliver a more accurate and improved conceptual design capable of delivering more decision support backgound | Design team | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Provide interface between platform & component. |
| F | BIM documentation<br>Concept design documentation<br>Simulation parameters | Preliminary simulations | Preliminary simulations report | to be able to assess the preliminary impact of the design on the studied criteria | Design team | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Provide interface between platform & component. |
| G | BIM documentation<br>Concept design documentation<br>LCA library | Preliminary Lifecycle assessment (LCA) | Preliminary LCA report | to be able to assess the preliminary impact of the design on the studied criteria | Design team | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Provide interface between platform & component. |
| H | BIM documentation<br>Concept design documentation | Early materials quantities/ mass/ BoQ: cost analysis | Bill of Quantity<br>Cost analysis report | to be able to deliver a preliminary cost assessment. | Design team | - Cost analysis and assessment.<br>- Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Provide interface between platform & component |
| I | BIM documentation<br>Concept design documentation<br>Workshop reports | Revision and finalising of the concept design (CREE, design team) | Final concept design | to be able to use the workshop feedback for the finalisation of conceptual design. | CREE | - Collect the final documentation.<br>- A final central model with the sub-models of the experts substantiated with additional documents such as fire protection concept, calculations of civil engineers, building physics experts, etc. |

**Figure 10.** Austrian Pilot Developed & Technical Design Phase Activity & Information Flow Process Diagram



**4. Developed & technical design**

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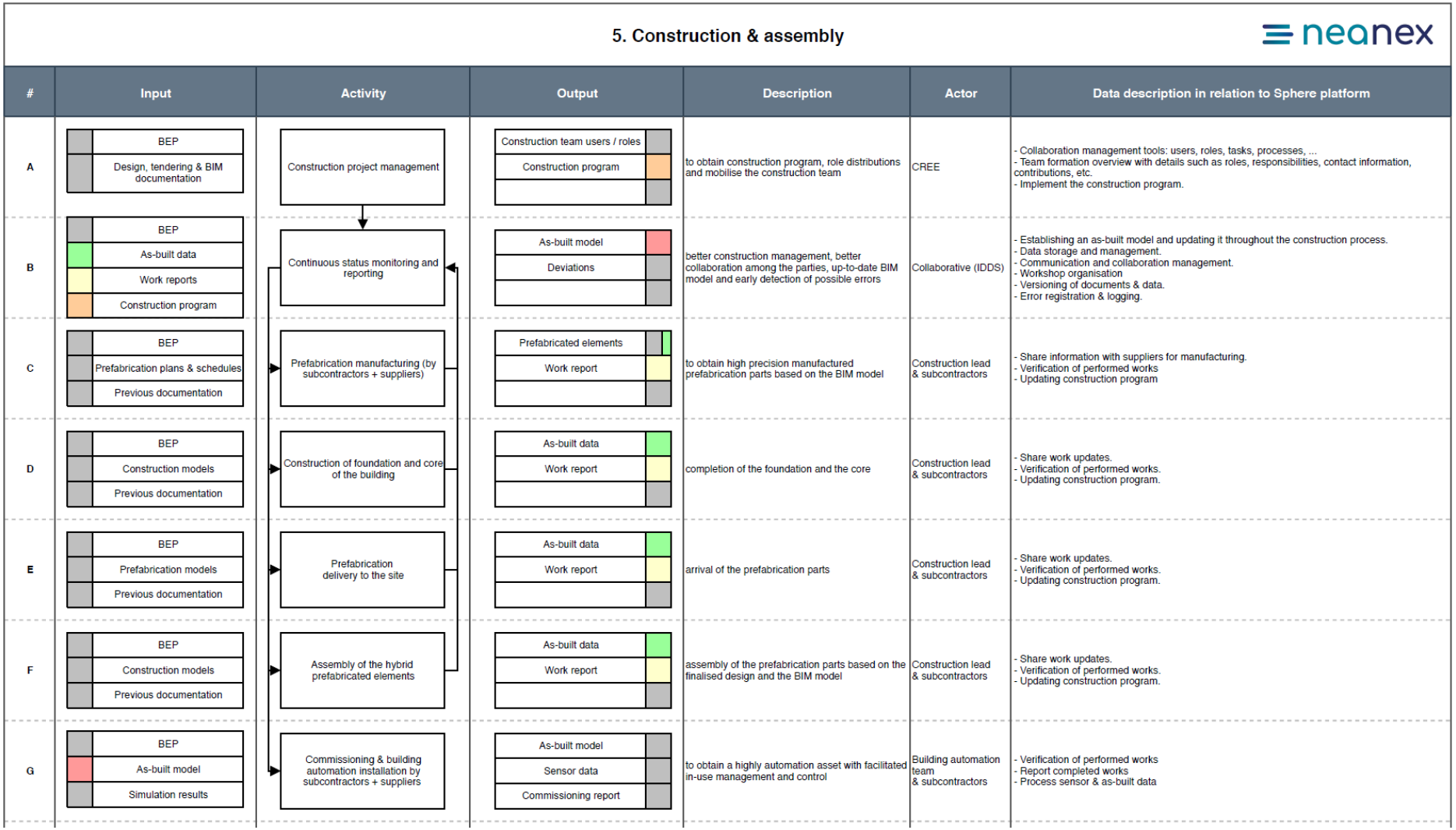
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Technical design documentation<br>Concept design documentation | Developed & technical design preparations | Design team users / roles<br>Management and strategy report | to be able to initiate detailed & technical design strategy and decisions | Project lead | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc. |
| B | Design documentation<br>BIM documentation | Design workshops (design team, project lead, building owner) | Workshop reports | to exchange ideas among the joining parties regarding developed & technical design | Collaborative (IDDS) | - Data storage and management.<br>- Communication and collaboration management.<br>- Workshop organisation.<br>- Versioning of documents & data. |
| C | Design documentation<br>BIM documentation | Developed & Technical design based on BIM | BIM model<br>Developed & technical design report | to form BIM objects and have a BIM model in order to achieve high level of automation and benefit from BIM | Design team | - Detailing of the model with attributes and attachments.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data. |
| D | Design documentation<br>Preliminary simulation results<br>BIM documentation | Simulations (energy, daylight, ventilation) | Simulations report | to anticipate the real time reaction of the asset under certain environmental conditions and further iterate the design based on the simulations results | Design team | - Updated libraries and integrated simulation reports/results.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Interface between BIM & simulations. |
| E | Design documentation<br>Preliminary LCA report<br>BIM documentation | Life cycle assessment (LCA) | LCA report | to be able to assess the environemtal impacts caused by the asset throug its life cycles (carbon footprint(embodied carbon, CO2 emissions etc) , raw material use..) | Design team | - Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Interface between BIM & LCA<br>- Export options. |
| F | Design documentation<br>BIM documentation | Contacting subcontractors and suppliers - Quotes for technical design | Tendering documentation | reaching out the potential candidate construction teams, requesting proposals and initiate the tendering process | CREE | - Contact register.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Interface between BIM & tendering |
| G | Design documentation<br>BIM documentation | Final material quantities/mass/ BoQ - cost analysis | Bill of Quantity<br>Cost analysis report | to assess the material inventory and ascociated cost based on the BIM model | Design team | - Final cost analysis<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Interface between BIM & Cost analysis |
| H | Design documentation<br>BIM documentation<br>Workshop reports | Revision and finalising of the developed and technical design | Final developed & technical design | to iterate the developed&technical design based on the workshop feedbacks, have a finalized design which all parties are satisfied with and updated BIM model | Design team | - Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data. |

**Figure 11.** Austrian Pilot Construction & Assembly / Renovation Phase Activity & Information Flow Process Diagram



## 5. Construction & assembly

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| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | BEP<br>Design, tendering & BIM documentation | Construction project management | Construction team users / roles<br>Construction program | to obtain construction program, role distributions and mobilise the construction team | CREE | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- Implement the construction program. |
| B | BEP<br>As-built data<br>Work reports<br>Construction program | Continuous status monitoring and reporting | As-built model<br>Deviations | better construction management, better collaboration among the parties, up-to-date BIM model and early detection of possible errors | Collaborative (IDDS) | - Establishing an as-built model and updating it throughout the construction process.<br>- Data storage and management.<br>- Communication and collaboration management.<br>- Workshop organisation<br>- Versioning of documents & data.<br>- Error registration & logging. |
| C | BEP<br>Prefabrication plans & schedules<br>Previous documentation | Prefabrication manufacturing (by subcontractors + suppliers) | Prefabricated elements<br>Work report | to obtain high precision manufactured prefabrication parts based on the BIM model | Construction lead & subcontractors | - Share information with suppliers for manufacturing.<br>- Verification of performed works<br>- Updating construction program |
| D | BEP<br>Construction models<br>Previous documentation | Construction of foundation and core of the building | As-built data<br>Work report | completion of the foundation and the core | Construction lead & subcontractors | - Share work updates.<br>- Verification of performed works.<br>- Updating construction program. |
| E | BEP<br>Prefabrication models<br>Previous documentation | Prefabrication delivery to the site | As-built data<br>Work report | arrival of the prefabrication parts | Construction lead & subcontractors | - Share work updates.<br>- Verification of performed works.<br>- Updating construction program. |
| F | BEP<br>Construction models<br>Previous documentation | Assembly of the hybrid prefabricated elements | As-built data<br>Work report | assembly of the prefabrication parts based on the finalised design and the BIM model | Construction lead & subcontractors | - Share work updates.<br>- Verification of performed works.<br>- Updating construction program. |
| G | BEP<br>As-built model<br>Simulation results | Commissioning & building automation installation by subcontractors + suppliers | As-built model<br>Sensor data<br>Commissioning report | to obtain a highly automation asset with facilitated in-use management and control | Building automation team & subcontractors | - Verification of performed works<br>- Report completed works<br>- Process sensor & as-built data |

**Figure 12.** Austrian Pilot Handover & Close Out Phase Activity & Information Flow Process Diagram

**6. Handover and close out**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin<br>Handover strategy | Undertake the tasks listed in the handover strategy | Completed handover | smooth and facilitated handover process | Project lead | - Digital Twin handover.<br>- Clear definition of Digital Twin information in the performance report and building automation data. |
| B | As-built model<br>Building automation data<br>Deviations | Manage updating of 'As built' information and monitor/ review progress and performance of construction | As-built model<br>Performance reports | up-to-date BIM model, verification of the progress documents as per defects and deviations based on BIM | Collaborative (IDDS) | - Provide custom exports to specific data according to the actor, such as building owner, planner, facility manager, ...<br>- Process building automation data and report<br>- Store as-built models & reports (+ versioning)<br>- Verification process |

**Figure 13**. Austrian Pilot In Use Phase Activity & Information Flow Process Diagram

**7. In use**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin | Takeover and deliver to occupants | Occupant users / roles<br>Facility manager | delivery | Building owner | - Facility management tool.<br>- Custom exports.<br>- New users & roles added for the asset maintenance. |
| B | Maintenance tasks<br>Simulation results | Continuous monitoring and reporting (to building owner and CREE) | Maintenance prediction<br>Building optimisation<br>Updated Digital Twin | to detect maintenance requirements, ensure occupant comfort, reduced operational costs (energy,water savings etc..) | Building owner | - Provide contacts for subcontractors/maintenance companies for dedicated maintenance or repairs.<br>- Continuous data monitoring and reporting.<br>- Alerts when action is required. |
| C | Maintenance tasks<br>Maintenance data<br>BIM model | Reactionary and planned maintenance | Maintenance users / roles<br>Maintenance reports<br>Updated asset data | effective maintenance planning with reduced operation time and cost, efficient and on time intervention | Maintenance Service Company | - Maintenance logs & reports.<br>- Maintenance users & roles.<br>- Alerts when action is required. |

## 6.2 Activity & Information Flow Process Diagrams For The Italian Pilot

**Figure 14.** Italian Pilot Strategic Definition Phase Activity & Information Flow Process Diagram

**1. Strategic definition**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Brief & target data/documents | Strategy and target setting | Brief template<br>Strategic brief export | Centric definition of tools, identification of metrics from pre-given options (e.g. energy, environmental performance, etc.) | Building owner (DE5) | - Project & collaboration management tools.<br>- Data integration, data standardisation and access to the data (for authorised actors).<br>- Brief template export & sharing options.<br>- Basic project information and requirements/targets stored as a standard form.<br>- Assessment of Digital Twin scope/configuration. |

**Figure 15**. Italian Pilot Preparation & Brief Phase Activity & Information Flow Process Diagram

## 2. Preparation and brief

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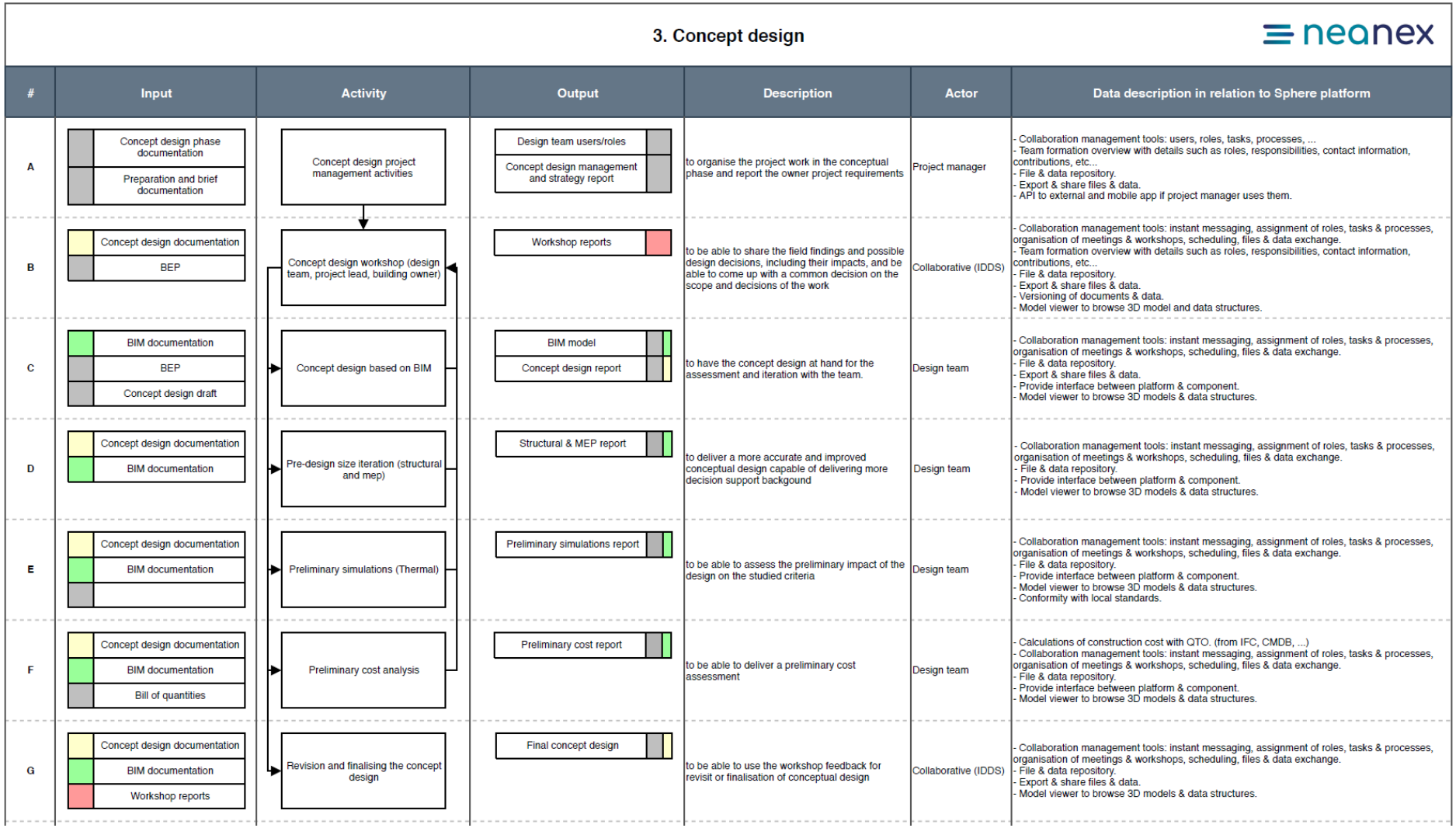
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Brief & target setting documents<br>Brief & target setting data | Start technical assessment and team formation | Team formation (users & roles)<br>Technical assessment info<br>Survey types<br>BEP | definition of roles and survey types with additional sustainability and acoustic surveys, technical assessment info and the establishment of a BEP to implement a BIM methodology | Project manager | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- Storage of technical assessment information (type of construction system or software used).<br>- Storage of brief & target setting data, including the survey data.<br>- Meeting agenda |
| B | Survey types<br>Previous findings | Surveying & data collection for BIM | Survey data<br>BIM model | to have an initial field assessment / data for BIM | Surveyors | - Assign survey tasks.<br>- File repository.<br>- Load survey templates based on survey types.<br>- Accommodate different types of survey data.<br>- Export and share documents/files processed on the platform. |
| C | Survey data<br>Preliminary cost calculation<br>BEP | Basic cost estimation | Basic cost estimation report | to be able to evaluate foreseen costs, discuss scope and possible design options | Project manager | - Calculations of construction cost in according to standard unit cost of a residential type building.<br>- Access to survey data & preliminary cost calculation.<br>- File repository for cost reports.<br>- Project management for timeline, work schedule, WBS, ... |
| D | Survey data<br>Basic cost estimation report<br>BEP | Assessment of site survey, cost and targets (DE5, building owner) | Site survey, costs and targets report | to be able to collect correct information from site and hire/ mobilise the related professionals for the work | Collaborative (IDDS) | - Both on- and offline meetings.<br>- Model viewer to browse 3D models and data structures.<br>- Access to survey data, BEP and basic cost estimation. The ability to discuss and assess. |

**Figure 16**. Italian Pilot Concept Design Phase Activity & Information Flow Process Diagram



### 3. Concept design

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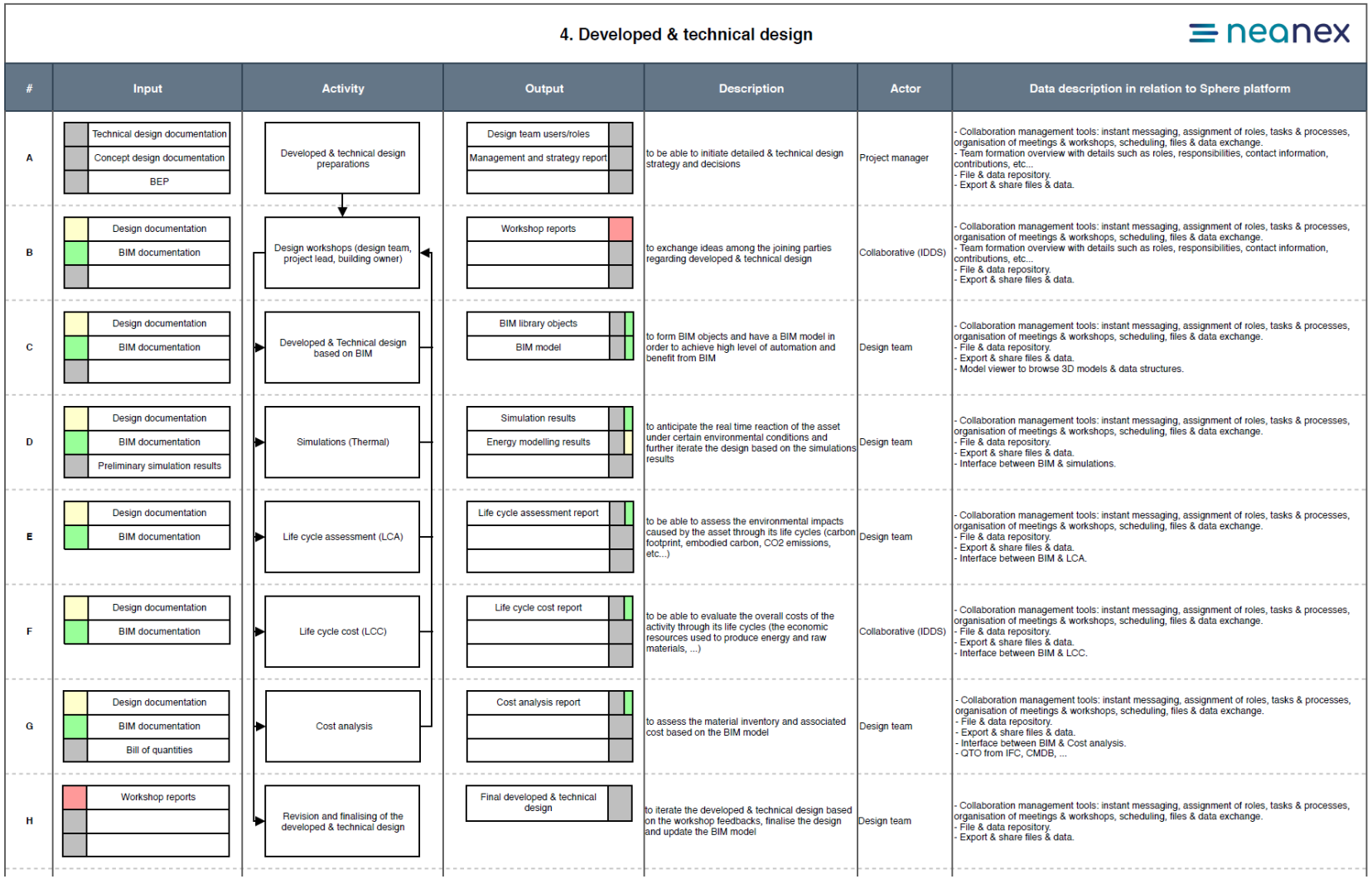
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Concept design phase documentation<br>Preparation and brief documentation | Concept design project management activities | Design team users/roles<br>Concept design management and strategy report | to organise the project work in the conceptual phase and report the owner project requirements | Project manager | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- File & data repository.<br>- Export & share files & data.<br>- API to external and mobile app if project manager uses them. |
| B | Concept design documentation<br>BEP | Concept design workshop (design team, project lead, building owner) | Workshop reports | to be able to share the field findings and possible design decisions, including their impacts, and be able to come up with a common decision on the scope and decisions of the work | Collaborative (IDDS) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data.<br>- Model viewer to browse 3D model and data structures. |
| C | BIM documentation<br>BEP<br>Concept design draft | Concept design based on BIM | BIM model<br>Concept design report | to have the concept design at hand for the assessment and iteration with the team. | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data.<br>- Provide interface between platform & component.<br>- Model viewer to browse 3D models & data structures. |
| D | Concept design documentation<br>BIM documentation | Pre-design size iteration (structural and mep) | Structural & MEP report | to deliver a more accurate and improved conceptual design capable of delivering more decision support backgound | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Provide interface between platform & component.<br>- Model viewer to browse 3D models & data structures. |
| E | Concept design documentation<br>BIM documentation | Preliminary simulations (Thermal) | Preliminary simulations report | to be able to assess the preliminary impact of the design on the studied criteria | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Provide interface between platform & component.<br>- Model viewer to browse 3D models & data structures.<br>- Conformity with local standards. |
| F | Concept design documentation<br>BIM documentation<br>Bill of quantities | Preliminary cost analysis | Preliminary cost report | to be able to deliver a preliminary cost assessment | Design team | - Calculations of construction cost with QTO. (from IFC, CMDB, ...)<br>- Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Provide interface between platform & component.<br>- Model viewer to browse 3D models & data structures. |
| G | Concept design documentation<br>BIM documentation<br>Workshop reports | Revision and finalising the concept design | Final concept design | to be able to use the workshop feedback for revisit or finalisation of conceptual design | Collaborative (IDDS) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data.<br>- Model viewer to browse 3D models & data structures. |

**Figure 17.** Italian Pilot Developed & Technical Design Phase Activity & Information Flow Process Diagram



**4. Developed & technical design**

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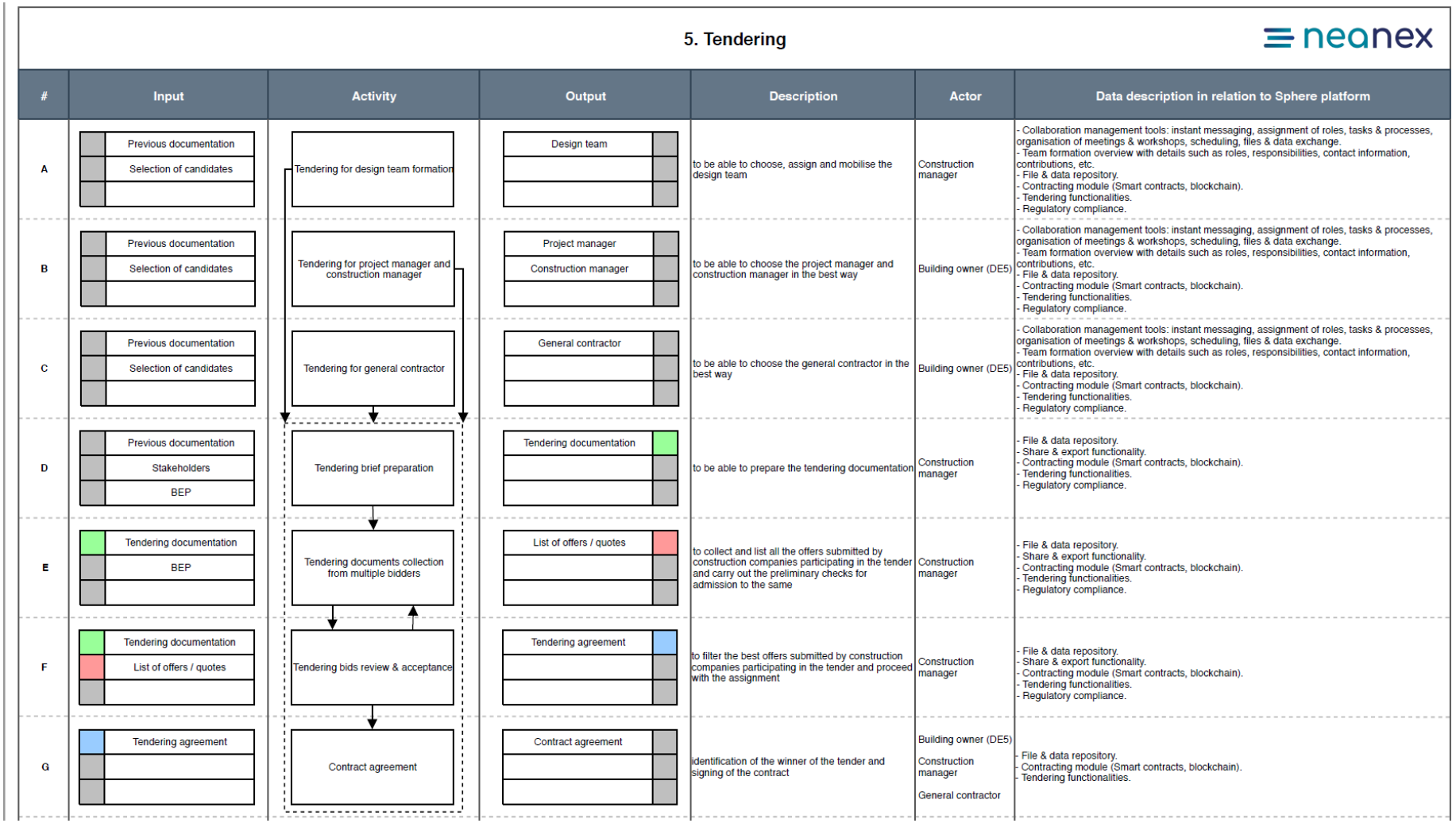
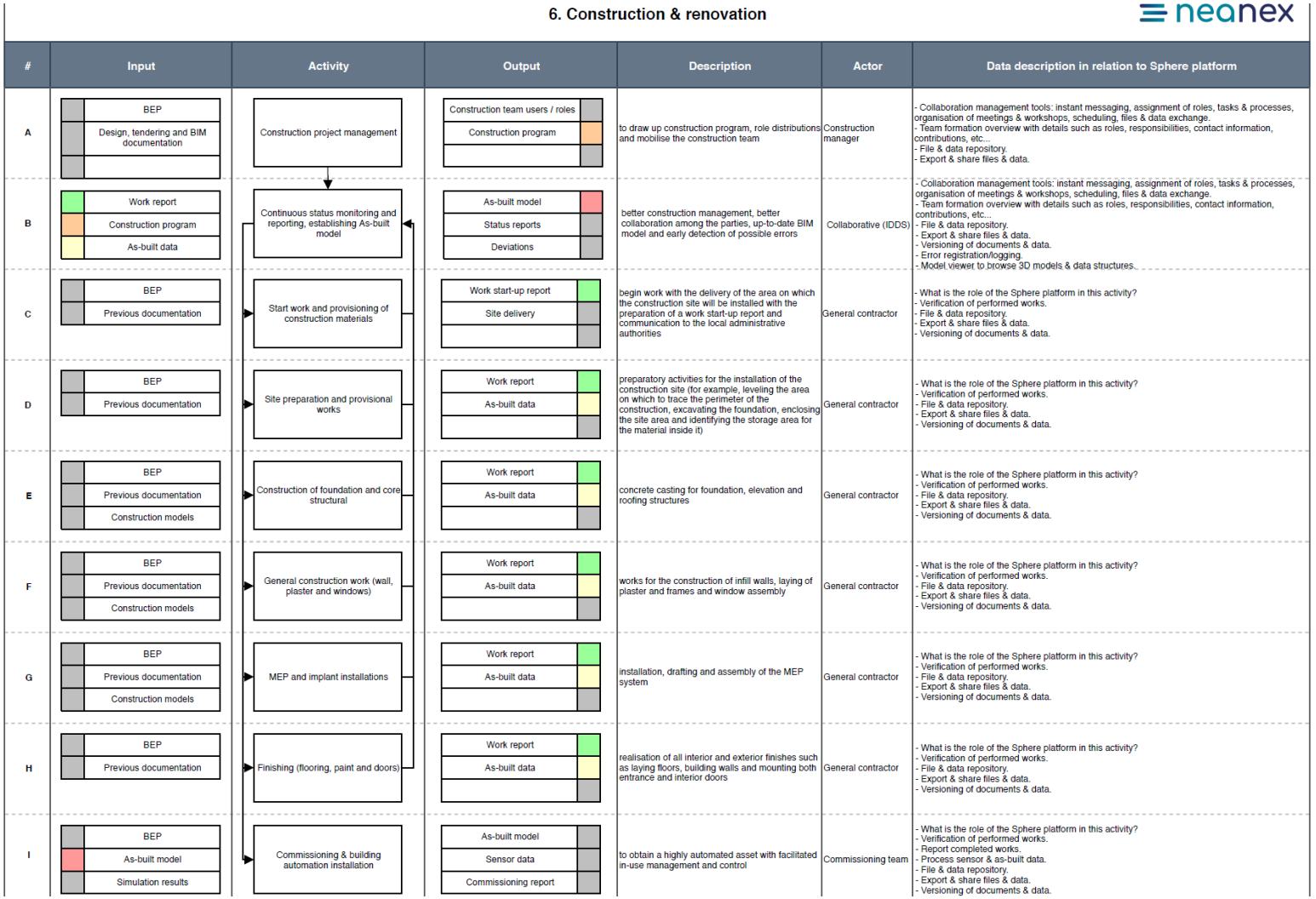
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Technical design documentation<br>Concept design documentation<br>BEP | Developed & technical design preparations | Design team users/roles<br>Management and strategy report | to be able to initiate detailed & technical design strategy and decisions | Project manager | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- File & data repository.<br>- Export & share files & data. |
| B | Design documentation<br>BIM documentation | Design workshops (design team, project lead, building owner) | Workshop reports | to exchange ideas among the joining parties regarding developed & technical design | Collaborative (IDDS) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- File & data repository.<br>- Export & share files & data. |
| C | Design documentation<br>BIM documentation | Developed & Technical design based on BIM | BIM library objects<br>BIM model | to form BIM objects and have a BIM model in order to achieve high level of automation and benefit from BIM | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data.<br>- Model viewer to browse 3D models & data structures. |
| D | Design documentation<br>BIM documentation<br>Preliminary simulation results | Simulations (Thermal) | Simulation results<br>Energy modelling results | to anticipate the real time reaction of the asset under certain environmental conditions and further iterate the design based on the simulations results | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data.<br>- Interface between BIM & simulations. |
| E | Design documentation<br>BIM documentation | Life cycle assessment (LCA) | Life cycle assessment report | to be able to assess the environmental impacts caused by the asset through its life cycles (carbon footprint, embodied carbon, CO2 emissions, etc...) | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data.<br>- Interface between BIM & LCA. |
| F | Design documentation<br>BIM documentation | Life cycle cost (LCC) | Life cycle cost report | to be able to evaluate the overall costs of the activity through its life cycles (the economic resources used to produce energy and raw materials, ...) | Collaborative (IDDS) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data.<br>- Interface between BIM & LCC. |
| G | Design documentation<br>BIM documentation<br>Bill of quantities | Cost analysis | Cost analysis report | to assess the material inventory and associated cost based on the BIM model | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data.<br>- Interface between BIM & Cost analysis.<br>- QTO from IFC, CMDB, ... |
| H | Workshop reports | Revision and finalising of the developed & technical design | Final developed & technical design | to iterate the developed & technical design based on the workshop feedbacks, finalise the design and update the BIM model | Design team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Export & share files & data. |

**Figure 18.** Italian Pilot Tendering Phase Activity & Information Flow Process Diagram




| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Previous documentation<br>Selection of candidates | Tendering for design team formation | Design team | to be able to choose, assign and mobilise the design team | Construction manager | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- File & data repository.<br>- Contracting module (Smart contracts, blockchain).<br>- Tendering functionalities.<br>- Regulatory compliance. |
| B | Previous documentation<br>Selection of candidates | Tendering for project manager and construction manager | Project manager<br>Construction manager | to be able to choose the project manager and construction manager in the best way | Building owner (DE5) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- File & data repository.<br>- Contracting module (Smart contracts, blockchain).<br>- Tendering functionalities.<br>- Regulatory compliance. |
| C | Previous documentation<br>Selection of candidates | Tendering for general contractor | General contractor | to be able to choose the general contractor in the best way | Building owner (DE5) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- File & data repository.<br>- Contracting module (Smart contracts, blockchain).<br>- Tendering functionalities.<br>- Regulatory compliance. |
| D | Previous documentation<br>Stakeholders<br>BEP | Tendering brief preparation | Tendering documentation | to be able to prepare the tendering documentation | Construction manager | - File & data repository.<br>- Share & export functionality.<br>- Contracting module (Smart contracts, blockchain).<br>- Tendering functionalities.<br>- Regulatory compliance. |
| E | Tendering documentation<br>BEP | Tendering documents collection from multiple bidders | List of offers / quotes | to collect and list all the offers submitted by construction companies participating in the tender and carry out the preliminary checks for admission to the same | Construction manager | - File & data repository.<br>- Share & export functionality.<br>- Contracting module (Smart contracts, blockchain).<br>- Tendering functionalities.<br>- Regulatory compliance. |
| F | Tendering documentation<br>List of offers / quotes | Tendering bids review & acceptance | Tendering agreement | to filter the best offers submitted by construction companies participating in the tender and proceed with the assignment | Construction manager | - File & data repository.<br>- Share & export functionality.<br>- Contracting module (Smart contracts, blockchain).<br>- Tendering functionalities.<br>- Regulatory compliance. |
| G | Tendering agreement | Contract agreement | Contract agreement | identification of the winner of the tender and signing of the contract | Building owner (DE5)<br>Construction manager<br>General contractor | - File & data repository.<br>- Contracting module (Smart contracts, blockchain).<br>- Tendering functionalities. |

**Figure 19.** Italian Pilot Construction & Assembly Phase Activity & Information Flow Process Diagram



**6. Construction & renovation**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | BEP<br>Design, tendering and BIM documentation | Construction project management | Construction team users / roles<br>Construction program | to draw up construction program, role distributions and mobilise the construction team | Construction manager | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- File & data repository.<br>- Export & share files & data. |
| B | Work report<br>Construction program<br>As-built data | Continuous status monitoring and reporting, establishing As-built model | As-built model<br>Status reports<br>Deviations | better construction management, better collaboration among the parties, up-to-date BIM model and early detection of possible errors | Collaborative (IDDS) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data.<br>- Error registration/logging.<br>- Model viewer to browse 3D models & data structures. |
| C | BEP<br>Previous documentation | Start work and provisioning of construction materials | Work start-up report<br>Site delivery | begin work with the delivery of the area on which the construction site will be installed with the preparation of a work start-up report and communication to the local administrative authorities | General contractor | - What is the role of the Sphere platform in this activity?<br>- Verification of performed works.<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data. |
| D | BEP<br>Previous documentation | Site preparation and provisional works | Work report<br>As-built data | preparatory activities for the installation of the construction site (for example, leveling the area on which to trace the perimeter of the construction, excavating the foundation, enclosing the site area and identifying the storage area for the material inside it) | General contractor | - What is the role of the Sphere platform in this activity?<br>- Verification of performed works.<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data. |
| E | BEP<br>Previous documentation<br>Construction models | Construction of foundation and core structural | Work report<br>As-built data | concrete casting for foundation, elevation and roofing structures | General contractor | - What is the role of the Sphere platform in this activity?<br>- Verification of performed works.<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data. |
| F | BEP<br>Previous documentation<br>Construction models | General construction work (wall, plaster and windows) | Work report<br>As-built data | works for the construction of infill walls, laying of plaster and frames and window assembly | General contractor | - What is the role of the Sphere platform in this activity?<br>- Verification of performed works.<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data. |
| G | BEP<br>Previous documentation<br>Construction models | MEP and implant installations | Work report<br>As-built data | installation, drafting and assembly of the MEP system | General contractor | - What is the role of the Sphere platform in this activity?<br>- Verification of performed works.<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data. |
| H | BEP<br>Previous documentation | Finishing (flooring, paint and doors) | Work report<br>As-built data | realisation of all interior and exterior finishes such as laying floors, building walls and mounting both entrance and interior doors | General contractor | - What is the role of the Sphere platform in this activity?<br>- Verification of performed works.<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data. |
| I | BEP<br>As-built model<br>Simulation results | Commissioning & building automation installation | As-built model<br>Sensor data<br>Commissioning report | to obtain a highly automated asset with facilitated in-use management and control | Commissioning team | - What is the role of the Sphere platform in this activity?<br>- Verification of performed works.<br>- Report completed works.<br>- Process sensor & as-built data.<br>- File & data repository.<br>- Export & share files & data.<br>- Versioning of documents & data. |

**Figure 20**. Italian Pilot Handover & Close Out Phase Activity & Information Flow Process Diagram

**7. Handover and close out**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin<br>Handover strategy | Undertake the tasks listed in the handover strategy | Completed handover | smooth and facilitated handover process | Construction manager | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Collecting building automation data.<br>- File & data repository. |
| B | As-built model<br>Building automation data<br>Deviations | Delivery of As built information and monitor/ review progress and performance of construction (design team construction manager) | As-built models<br>Performance reports | up-to-date BIM model, verification of the progress documents as per defects and deviations based on BIM | Collaborative (IDDS) | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Process building automation data and report.<br>- File & data repository.<br>- Versioning of documents & data.<br>- Verification process.<br>- Model viewer to check as-built data. |

**Figure 21.** Italian Pilot In Use Phase Activity & Information Flow Process Diagram

**8. In use**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin | Takeover and deliver to occupants | Occupant user / roles<br>Facility manager | delivery | Building owner | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- File & data repository.<br>- Contracting module (Smart contracts, blockchain)<br>- Export & share files & data. |
| B | Maintenance tasks<br>Simulation results<br>Digital Twin | Continuous monitoring and reporting (to building owner and DE5) | Maintenance prediction<br>Building optimisation<br>Updated Digital Twin | to detect maintenance requirements, ensure occupant comfort, reduced operational costs (energy, water savings etc..) | Building automation team | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Continuous data monitoring and reporting.<br>- Alerts when action is required.<br>- File & data repository. |
| C | Maintenance tasks<br>Maintenance data<br>BIM model | Reactionary and planned maintenance | Maintenance reports<br>Updated asset data | effective maintenance planning with reduced operation time and cost, efficient and on time intervention | Maintenance Service Company | - Collaboration management tools: instant messaging, assignment of roles, tasks & processes, organisation of meetings & workshops, scheduling, files & data exchange.<br>- Maintenance logs/ tracking.<br>- Alerts when action is required.<br>- Model viewer to check & coordinate maintenance operation and cost verification.<br>- Tools to optimise maintenance efficiency.<br>- File & data repository. |

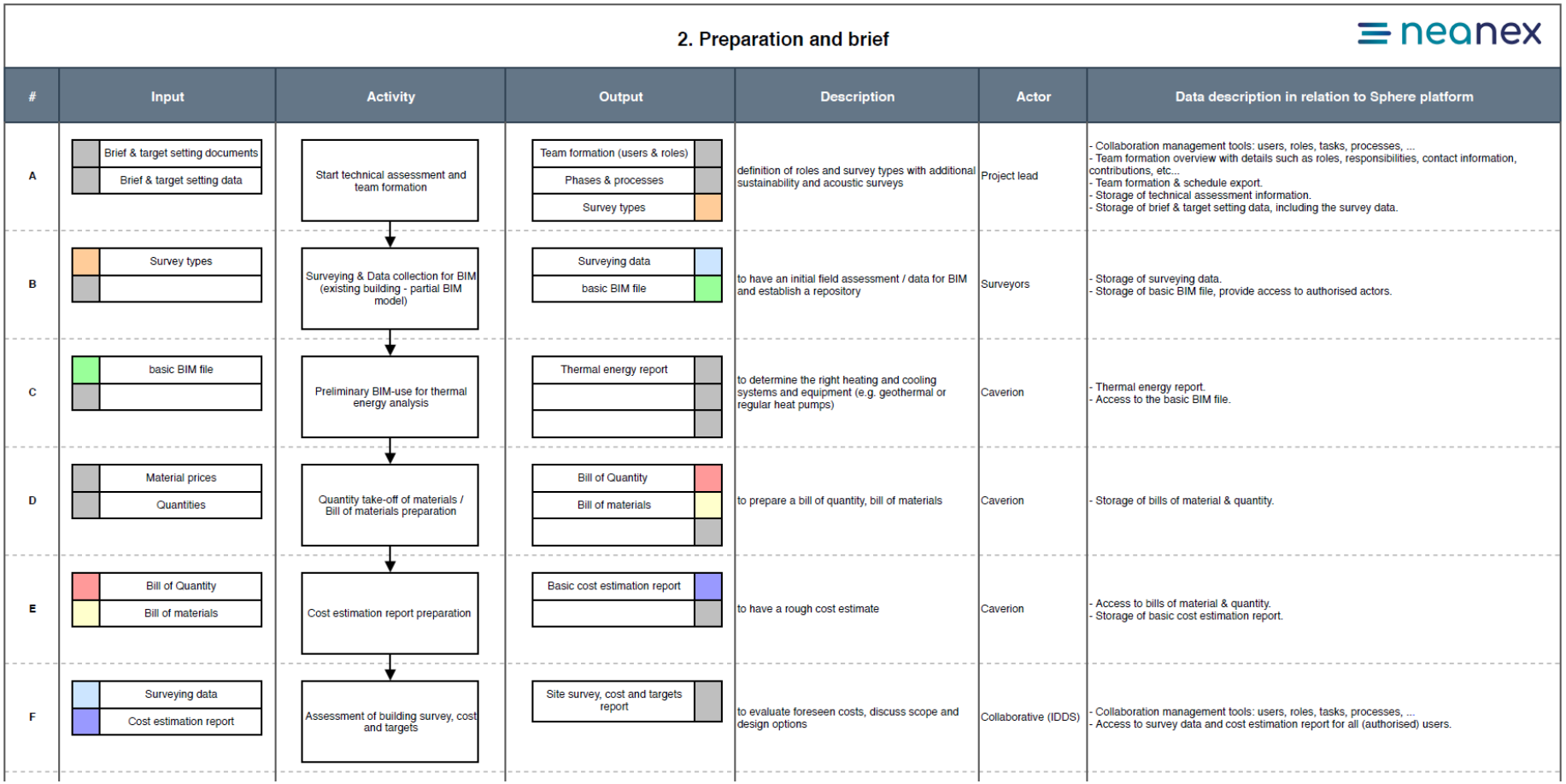
## 6.3 Activity & Information Flow process diagrams for the Finnish Pilot

**Figure 22**. Finnish Pilot Strategic Definition Phase Activity & Information Flow Process Diagram

**1. Strategic definition**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Brief & target data/documents | Strategy and target setting | Brief template<br>Strategic brief export | To be able to identify the overarching objective and performance criteria of the project | Caverion | - Project & collaboration management tools.<br>- Data integration, data standardisation and access to the data (for authorised actors).<br>- Brief template export & sharing options.<br>- Basic project information and requirements/targets stored as a standard form.<br>- Assessment of Digital Twin scope/configuration. |

**Figure 23.** Finnish Pilot Preparation & Brief Phase Activity & Information Flow Process Diagram



## 2. Preparation and brief

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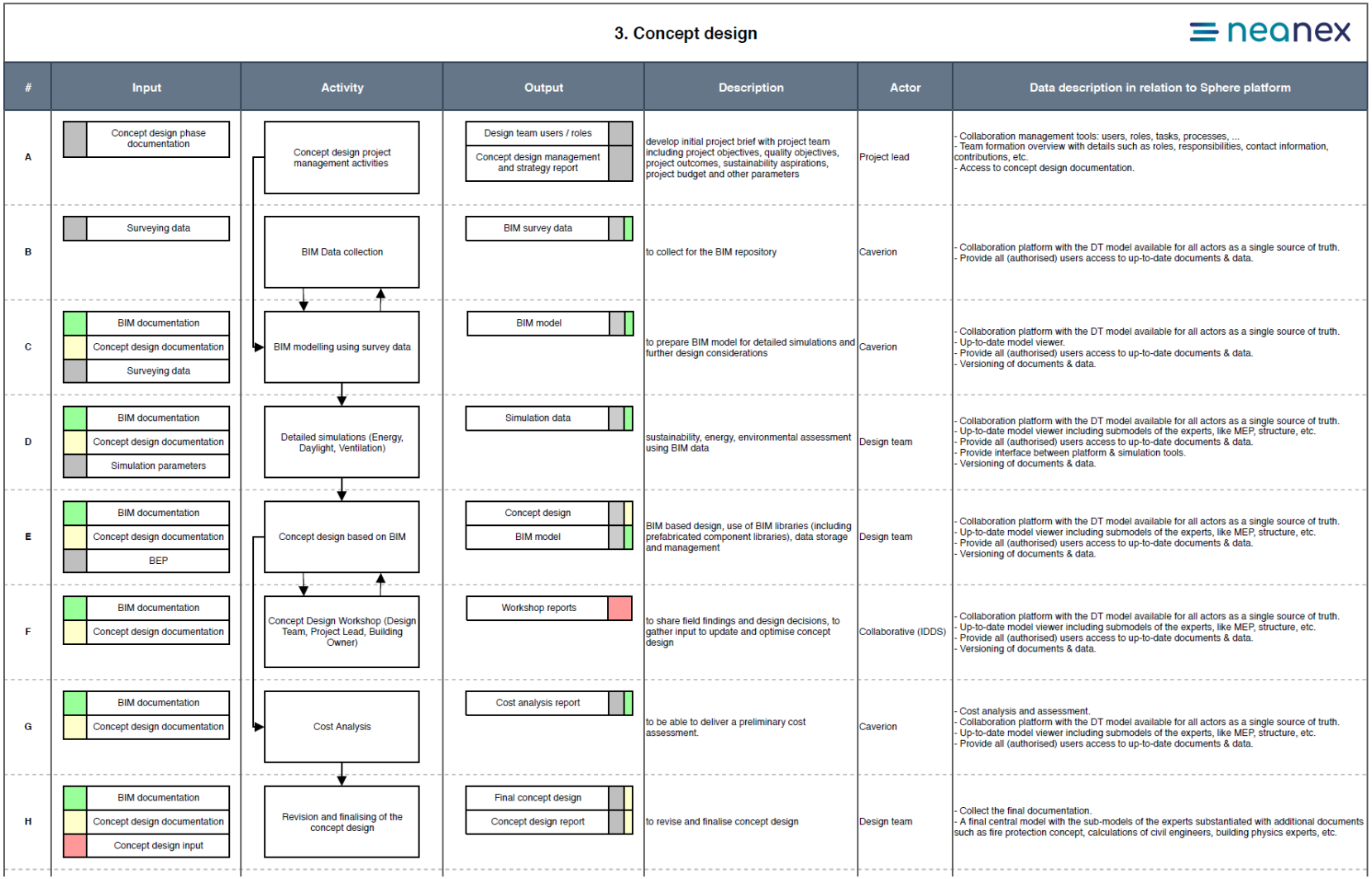
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Brief & target setting documents<br>Brief & target setting data | Start technical assessment and team formation | Team formation (users & roles)<br>Phases & processes<br>Survey types | definition of roles and survey types with additional sustainability and acoustic surveys | Project lead | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- Team formation & schedule export.<br>- Storage of technical assessment information.<br>- Storage of brief & target setting data, including the survey data. |
| B | Survey types | Surveying & Data collection for BIM (existing building - partial BIM model) | Surveying data<br>basic BIM file | to have an initial field assessment / data for BIM and establish a repository | Surveyors | - Storage of surveying data.<br>- Storage of basic BIM file, provide access to authorised actors. |
| C | basic BIM file | Preliminary BIM-use for thermal energy analysis | Thermal energy report | to determine the right heating and cooling systems and equipment (e.g. geothermal or regular heat pumps) | Caverion | - Thermal energy report.<br>- Access to the basic BIM file. |
| D | Material prices<br>Quantities | Quantity take-off of materials / Bill of materials preparation | Bill of Quantity<br>Bill of materials | to prepare a bill of quantity, bill of materials | Caverion | - Storage of bills of material & quantity. |
| E | Bill of Quantity<br>Bill of materials | Cost estimation report preparation | Basic cost estimation report | to have a rough cost estimate | Caverion | - Access to bills of material & quantity.<br>- Storage of basic cost estimation report. |
| F | Surveying data<br>Cost estimation report | Assessment of building survey, cost and targets | Site survey, cost and targets report | to evaluate foreseen costs, discuss scope and design options | Collaborative (IDDS) | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Access to survey data and cost estimation report for all (authorised) users. |

**Figure 24.** Finnish Pilot Concept Design Phase Activity & Information Flow Process Diagram



### 3. Concept design

neanex

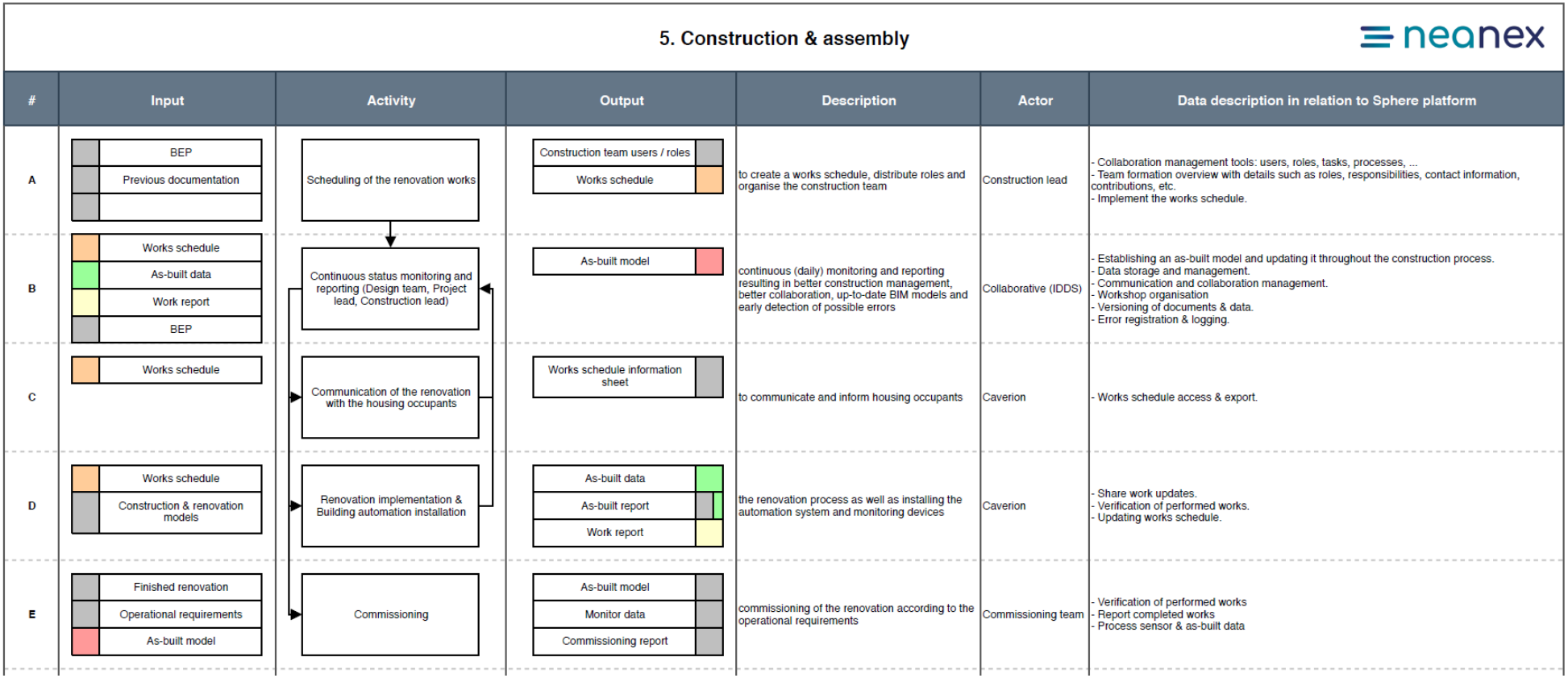
| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Concept design phase documentation | Concept design project management activities | Design team users / roles<br>Concept design management and strategy report | develop initial project brief with project team including project objectives, quality objectives, project outcomes, sustainability aspirations, project budget and other parameters | Project lead | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- Access to concept design documentation. |
| B | Surveying data | BIM Data collection | BIM survey data | to collect for the BIM repository | Caverion | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Provide all (authorised) users access to up-to-date documents & data. |
| C | BIM documentation<br>Concept design documentation<br>Surveying data | BIM modelling using survey data | BIM model | to prepare BIM model for detailed simulations and further design considerations | Caverion | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Versioning of documents & data. |
| D | BIM documentation<br>Concept design documentation<br>Simulation parameters | Detailed simulations (Energy, Daylight, Ventilation) | Simulation data | sustainability, energy, environmental assessment using BIM data | Design team | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Provide interface between platform & simulation tools.<br>- Versioning of documents & data. |
| E | BIM documentation<br>Concept design documentation<br>BEP | Concept design based on BIM | Concept design<br>BIM model | BIM based design, use of BIM libraries (including prefabricated component libraries), data storage and management | Design team | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Versioning of documents & data. |
| F | BIM documentation<br>Concept design documentation | Concept Design Workshop (Design Team, Project Lead, Building Owner) | Workshop reports | to share field findings and design decisions, to gather input to update and optimise concept design | Collaborative (IDDS) | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Versioning of documents & data. |
| G | BIM documentation<br>Concept design documentation | Cost Analysis | Cost analysis report | to be able to deliver a preliminary cost assessment. | Caverion | - Cost analysis and assessment.<br>- Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data. |
| H | BIM documentation<br>Concept design documentation<br>Concept design input | Revision and finalising of the concept design | Final concept design<br>Concept design report | to revise and finalise concept design | Design team | - Collect the final documentation.<br>- A final central model with the sub-models of the experts substantiated with additional documents such as fire protection concept, calculations of civil engineers, building physics experts, etc. |

**Figure 25**. Finnish Pilot Developed & Technical Design Phase Activity & Information Flow Process Diagram

**4. Developed & technical design**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | | Given the size of the project - no iteration of technical design | | to review and update project execution plan (BEP) based on the given size of the project (no iteration of technical design) | Project lead | |

**Figure 26**. Finnish Pilot Construction and Assembly / Renovation Phase Activity & Information Flow Process Diagram



## 5. Construction & assembly

neanex

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | BEP<br>Previous documentation | Scheduling of the renovation works | Construction team users / roles<br>Works schedule | to create a works schedule, distribute roles and organise the construction team | Construction lead | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- Implement the works schedule. |
| B | Works schedule<br>As-built data<br>Work report<br>BEP | Continuous status monitoring and reporting (Design team, Project lead, Construction lead) | As-built model | continuous (daily) monitoring and reporting resulting in better construction management, better collaboration, up-to-date BIM models and early detection of possible errors | Collaborative (IDDS) | - Establishing an as-built model and updating it throughout the construction process.<br>- Data storage and management.<br>- Communication and collaboration management.<br>- Workshop organisation<br>- Versioning of documents & data.<br>- Error registration & logging. |
| C | Works schedule | Communication of the renovation with the housing occupants | Works schedule information sheet | to communicate and inform housing occupants | Caverion | - Works schedule access & export. |
| D | Works schedule<br>Construction & renovation models | Renovation implementation & Building automation installation | As-built data<br>As-built report<br>Work report | the renovation process as well as installing the automation system and monitoring devices | Caverion | - Share work updates.<br>- Verification of performed works.<br>- Updating works schedule. |
| E | Finished renovation<br>Operational requirements<br>As-built model | Commissioning | As-built model<br>Monitor data<br>Commissioning report | commissioning of the renovation according to the operational requirements | Commissioning team | - Verification of performed works<br>- Report completed works<br>- Process sensor & as-built data |

**Figure 27**. Finnish Pilot Handover and Close Out Phase Activity & Information Flow Process Diagram

**6. Handover and close out**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin<br>Handover strategy | Undertake the tasks listed in the handover strategy | Completed handover | smooth and facilitated handover process | Construction lead | - Digital Twin handover.<br>- Clear definition of Digital Twin information in the performance report and building automation data. |
| B | As-built model<br>Building automation data<br>Deviations | Manage updating of 'As built' information and monitor/review progress and performance of construction | As-built model<br>Performance reports | up-to-date BIM model, verification of the progress documents as per defects and deviations based on BIM | Design team | - Provide custom exports to specific data according to the actor, such as building owner, planner, facility manager, ...<br>- Process building automation data and report<br>- Store as-built models & reports (+ versioning)<br>- Verification process |

**Figure 28**. Finnish Pilot In Use Phase Activity & Information Flow Process Diagram

**7. In use**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin | Deliver to building owner and service company that operates the building | Occupant users / roles | delivery | Building owner | - Facility management tool.<br>- Custom exports.<br>- New users & roles added for the asset maintenance. |
| B | Digital Twin<br>Maintenance tasks<br>Building automation data | Continuous monitoring and reporting (to building owner and Caverion) | Digital Twin<br>Building optimisation<br>Maintenance prediction | data provided from building automation system, directly provided to Caverion | Building automation | - Provide contacts for subcontractors/maintenance companies for dedicated maintenance or repairs.<br>- Continuous data monitoring and reporting.<br>- Alerts when action is required. |
| C | Digital Twin<br>Building automation data | Update the digital data during the in-use phase (in parallel with maintenance) | Updated asset data | digital energy data, BIM data, maintenance information | Caverion | - Continuous data monitoring and reporting.<br>- Asset data update.<br>- Alerts when action is required. |
| D | Digital Twin<br>Maintenance tasks<br>Maintenance data | Reactionary and planned maintenance | Maintenance users / roles<br>Maintenance reports<br>Updated asset data | effective maintenance planning with reduced operation time and cost, efficient and on time intervention | Maintenance Service Company | - Maintenance logs & reports.<br>- Maintenance users & roles.<br>- Alerts when action is required. |

## 6.4 Activity & Information Flow Process Diagrams for The Netherlands Pilot

**Figure 29.** Netherlands Pilot Activities for Strategic Definition Information Flow Process Diagram

**1. Strategic definition**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Brief & target data/documents | Strategy and target setting | Brief template<br>Strategic brief export | To be able to identify the overarching objective and performance criteria of the project with focus on energy and thermal comfort | TNO, Koppen Bouwexpert | -Format of KPI on thermal comfort and energy demand<br>-Data integration, data standardisation and access to the data (for authorised actors).<br>- Brief template export & sharing options.<br>- Basic project information and requirements/targets stored as a standard form.<br>- Assessment of Digital Twin scope/configuration. |

**Figure 30.** Netherlands Pilot Activities for Preparation and Brief Activity & Information Flow Process Diagram

**2. Preparation and brief**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | B&T setting documents<br>B&T setting data | Start technical assessment and team formation | Team formation (users<br>Phases & processes | definition of roles | TNO / Bouwexperts | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc...<br>- Team formation & schedule export.<br>- . |
| B | First 3D drafts | First 3D drafts | basic BIM file | to have an initial data for BIM and establish a repository | Koppen Bouwexperts | -<br>- Storage of basic BIM file, provide access to authorised actors. |
| C | basic BIM file | Preliminary BIM-use for thermal energy analysis | Thermal energy report<br>Energy caclulations | to determine the right heating and cooling systems and equipment (e.g. geothermal or regular heat pumps) | TNO<br>Koppen Bouwexperts | - Thermal energy report.<br>- Access to the basic BIM file<br>- Energy calculation report. |

**Figure 31**. Netherlands Pilot Activities for Design phases Activity & Information Flow Process Diagram

3. Concept design

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Concept design phase documentation | Concept design project management activities | Design team users / Concept design management and strategy report | develop initial project brief with project team including project objectives, quality objectives, project outcomes, sustainability aspirations, project budget and other parameters | TNO | - Collaboration management tools: users, roles, tasks, processes, ...<br>- Team formation overview with details such as roles, responsibilities, contact information, contributions, etc.<br>- Access to concept design documentation. |
| B | Surveying data | BIM Data collection | BIM survey data | to collect for the BIM repository | TNO | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Provide all (authorised) users access to up-to-date BIM file. |
| C | BIM documentation<br>Concept design<br>Surveying data | BIM modelling using survey data | BIM model | to prepare BIM model for detailed simulations and further design considerations | TNO | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer.<br>- Provide all (authorised) users access to up-to-date documents & data.<br>- Versioning of BIM & data. |
| D | BIM documentation<br>Concept design<br>Simulation parameters | Detailed simulations (Energy, Thermal comfort) | Simulation data | Energy and thermal comfortt using BIM data | TNO & Koppen Bouwexperts | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date BIM model<br>- Provide all (authorised) users access to up-to-date BIM model & data.<br>- Provide interface between platform & simulation tools.<br>- Versioning of BIM & data. |
| E | BIM documentation<br>Concept design<br>BEP | Concept design based on BIM | Concept design<br>BIM model | BIM based design, use of BIM libraries (including prefabricated component libraries), data storage and management | TNO & Koppen Bouwexperts & Contractor & Manufactorer | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date BIM model<br>- Provide all (authorised) users access to up-to-date BIM Model & data.<br>- Versioning of documents & data. |
| F | BIM documentation<br>Concept design documentation | Concept Design Workshop (Design Team, Project Lead, Building Owner) | Workshop reports | to share field findings and design decisions, to gather input to update and optimise concept design | Collaborative (IDDS) TNO & Koppen Bouwexperts & Contrator & Manufactorer | - Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date BIM model<br>- Provide all (authorised) users access to up-to-date BIM model & data.<br>- Versioning of BIM Model & data. |
| G | BIM documentation<br>Concept design documentation | Energy and thermal analysis | Energy and thermal comfort analysis | to be able to deliver a preliminary thermal and energy analysis | TNO & Koppen Bouwexperts | - Cost analysis and assessment.<br>- Collaboration platform with the DT model available for all actors as a single source of truth.<br>- Up-to-date model viewer including submodels of the experts, like MEP, structure, etc.<br>- Provide all (authorised) users access to up-to-date documents & data. |
| H | BIM documentation<br>Concept design documentation<br>Concept design input | Revision and finalising of the concept design | Final concept design<br>Concept design report | to revise and finalise concept design | Koppen Bouwexperts | Collect the final BIM file |

**Figure 32.** Netherlands Pilot Activities for Handover and Close Out phases Activity & Information Flow Process Diagram

6. Handover and close out

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin<br>Handover strategy | Undertake the tasks listed in the handover strategy | Completed handover | smooth and facilitated handover process | TNO / Koppen Bouwexperts | - Digital Twin handover.<br>- Clear definition of Digital Twin information in the performance report and building automation data. |
| B | As-built model<br>Building automation<br>Deviations | Manage updating of 'As built' information and monitor/review progress and performance of construction | As-built model<br>Performance reports | up-to-date BIM model, verification of the performance of building and system as per defects and deviations based on BIM | TNO /Koppen Bouwexperts /Contractor / Manufactorer | - Provide custom exports to specific data according to the actor, such as building owner, planner, facility manager, ...<br>- Process building automation data and report<br>- Store as-built models & reports (+ versioning)<br>- Verification process |

**Figure 33:** Netherlands Pilot Activities for In Use Phase Activity & Information Flow Process Diagram

**7. In use**

| # | Input | Activity | Output | Description | Actor | Data description in relation to Sphere platform |
|---|---|---|---|---|---|---|
| A | Digital Twin | Deliver to building owner and Developer (NeroZero bv) responsable for the performance contractors | Occupant users / roles | delivery | Building owner/occupant<br>Developer<br>TNO<br>Koppen<br>Bouwexperts | - Micro services for energy and thermal comfort.<br>-. |
| B | Digital Twin<br>Maintenance tasks<br>Building automation data | Continuous monitoring and reporting (to building owner and Nero Zero Bv) | Digital Twin<br>Energy performance<br>Thermal comfort | data provided for calculation thermal comfort and energy | TNO<br>Koppen Bouw Experts<br>Manufacturer | - Provide information for<br>- Continuous data monitoring and reporting. |
| C | Digital Twin<br>Building automation | Update the digital data during the in-use phase (in parallel with maintenance) | Updated Digital twin | digital energy data, BIM data, updated parameters of digital twins | TNO | - Continuous data monitoring and reporting.<br>- Digital Twin update. |
| D | Digital Twin<br>Maintenance tasks<br>Maintenance data | Comparing garanteed performanceon energy and thermal comfort with actual performance | Feedback to<br>Feeedback to occupant<br>Complaince or non-compliance | Deriviation in performance, insight in causes either to occupant behaviour or buidling and installation performance | Nero Zero BV | Performance reports<br>Compliance |

# 7. User Scenarios and Interface Mock-ups

The series of user stories as identified in Chapter 5 can also be divided based on the roles for each type of AECO stakeholder. As such a pattern emerges of what user stories and related sub-modules a particular role, such as an architect or a building facility manager would carry out, and what interactions with the platform can be foreseen. A synthesis has been made based on the summary from the platform from these works as delivered in this chapter, in addition to an initial archetypical user interface that provides for the flexibility to deliver a scenario driven click-through for a user.

This Chapter will draw on the SPHERE platform functionality requirements and specifications, identified above, to produce a mock-up design of the SPHERE end-user platform. UCD and UX related principles will be used to justify the general aesthetic which is being displayed. This is an iterative process and therefore this deliverable aims to solely provide a basic foundation to be built upon in following work pages of the SPHERE project.

## 7.1 User Based UX Design

The platform will be of functional use for a variety of users during the lifecycle of a construction/renovation project. The general aesthetic of the SPHERE platform must remain consistent to ensure corporate identity and therefore the variety of users engaging with the platform must be considered in its design. The platform will be tailored to user groups, providing limited access to functionalities and stored documents. This will be achieved through admin-controlled authorisation for the logged in user.

A grid service listing approach will be used a basis for interfaces, this provides users with a clear overview of the functionalities available as well as providing guidance of the path to be followed to complete each user story experience. This will adhere to the simplicity and predictability usability heuristics. In addition, the platform will draw on the usability heuristics as shown in Figure 34 below to ensure that functionalities are clear and platform engagement experience is highly rated. [1]

| **20 Usability Heuristics** | |
|---|---|
| **User Control** | Technical Clarity |
| **Human Limitations** | Flexibility |
| **Modal Integrity** | Fulfilment |
| **Accommodation** | Cultural Property |
| **Linguistic Clarity** | Sustainable Tempo |
| **Aesthetic Integrity** | Consistency |
| **Simplicity** | User Support |
| **Predictability** | Precision |
| **Interpretation** | Forgiveness |
| **Accuracy** | Responsiveness |

**Figure 34**. Overview of heuristics to take into account for user experiences

[1] Weinschenk, S. & Barker, D., 2000. *Designing Effective Speech Interfaces / Weinschenk, Susan.* 1st ed.,

## 7.2 Adaptive UI Design Allowing Potential Scenarios for Backend Integration

The mock-ups for the SPHERE platform are presented with the potential to firstly use the services as external cloud services with existing user interfaces, where the whole service is delivered in the SPHERE platform within a container (frame). And secondly for the SPHERE platform to reach out to those services and calls via the predefined APIs based on the required functionalities and provide the received data and information into a standalone user interface.

### 7.2.1 Platform Interfaces

Here we will define potential navigational features that would successfully integrate the functionality requirements of the platform along with guiding users through the user stories in a cohesive and simple way.

**Table 36.** Operation of the SPHERE Platform is managed in two ways (pillars)

| Life Cycle Phases | Direct access menu items |
|---|---|
| **Strategic Definition** | Messages |
| **Preparation and Brief** | Team |
| **Concept Design** | Tasks |
| **Developed and Technical Design** | Repository |
| **Construction and Assembly/ Renovation** | Synch |
| **Hand over and Close Out** | Account |
| **In Use** | |

### 7.2.2 User Story Example

In order to demonstrate the potential use of the platform a mock-up of the interfaces that meet the requirements of an example user story is developed. During the course of the previous tasks, tasks in each phase for the pilots and the use of SPHERE Platform sub modules in each task were identified. Then software tool providers were asked to match their software with the SPHERE sub modules considering the functionalities of their software product. Based on these works, a mock-up for the User Story 34 in the Austrian Workflow is demonstrated.

**Austrian Pilot: User Story 34 (Hand over & Close out)**
After the Construction/Assembly Phase and commissioning of the asset, the Property Manager and Building Automation Team want to undertake the tasks listed in the Handover Strategy in order to achieve a smooth and facilitated handover process. As identified during the workshops with CREE**,** to carry on these activities on SPHERE Platform, Property Manager and Building Automation Team need to use the submodules ; *I4.M2.SM4 Progress Monitoring I4.M6.SM1 Handover Data Management,* which are matched with Flink2Go and Refurbify respectively.

To traverse through the user interface the user will carry out a selection of actions based on the building phase they are interested in (in the example handover and close out), and then select the desired operation of interest. An example this is shown below.

**Actions:** Select Phase Tasks menu → Select Hand Over and Close Out → Select Construction Operation → **Select I4.M.2.SM4. Progress Monitoring:** Constantly monitor the progress


**Figure 35**. Example Home Landing Page Interface

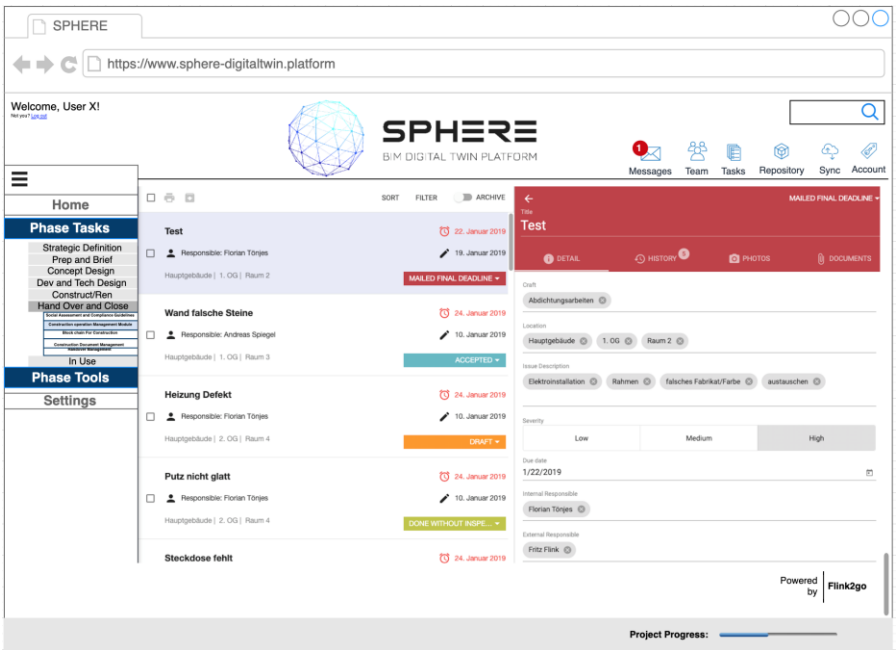



**Figure 36.** Sample Screenshot of the progress monitoring tool Flink2Go in SPHERE Platform

To proceed to other task user has to do the followings using the Handover & Close out menu → Select Handover Management Module → **Select I4.M.6.SM1. Handover Data Management:** Complete the handover using the building automation data and the Handover strategy

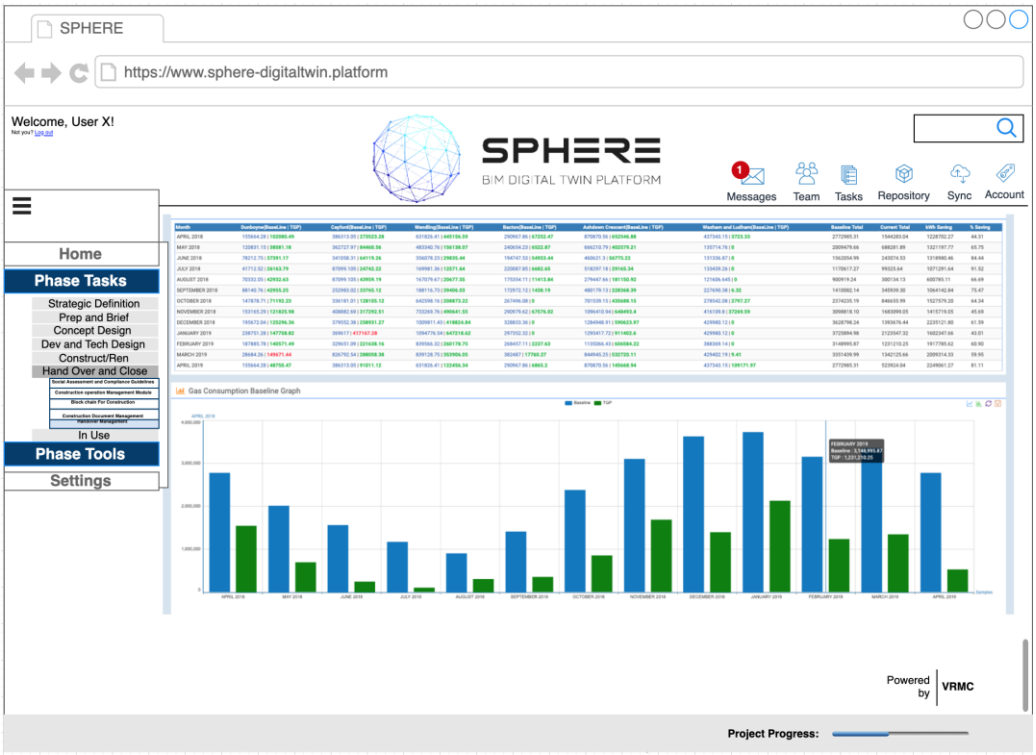



**Figure 37**. FLINK2GO Handover and Close Out with a different interface in the SPHERE wrapper

Once the task is completed → Select SPHERE icon to return to home screen or log out.

## 7.3 Future Interface Works:

As previously mentioned, these mock-ups aim to provide an initial overview of how platform functionalities will be integrated aesthetically into the SPHERE platform. This will be continued and expanded by the following work packages:

- **Task 2.4**: will carry out the User Centric Design and User Experience approach to ensure that the platform meets the usability heuristics.
- **WP3:** will deliver the architecture that will have an impact on the grid and presentation approach
- **WP4 and WP5:** will deliver the customised services of the platform along with further design and UX specifications. Additionally, within these work packages decisions on the use of style sheets and corporate identity shall be made to finalise the SPHERE platform aesthetic

# 8 Agile Development Methodology

## 8.1 What is Agile Development

Agile methodology allows the continuous iteration of development and testing throughout the software development life cycle of the project[2]. Known and expected benefits include:

- Stakeholder Engagement
- Transparency
- Early and Predictable Delivery
- Predictable Costs and Schedule
- Allows for Change
- Focuses on Business Value
- Focuses on Users
- Improves Quality

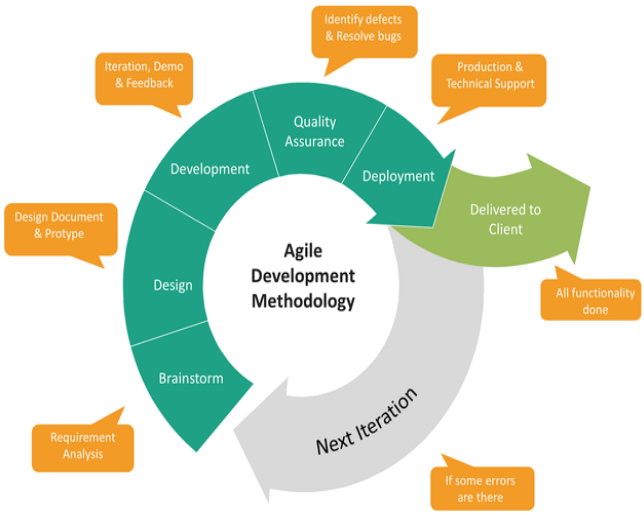



**Figure 38.** Agile development process and product launch stages

The process allows the delivery of selected (if necessary unstructured) components of the complete flow. The usually less formal and reduced scope of this approach also allows to speed up or bypass one or more life cycle phases when necessary.
Considering the interdisciplinary and complex requirements of the SPHERE project, a lot of which are very dependent on the digital building twin data structures that are emerging, the agile approach appears as a very good option for the continuous development of the functionalities.

The pilot actions and the various stakeholders involved in the pilots will also serve as a client-side feedback and approval mechanism in the project. The continuous development approach is also compliant with the cloud-based PaaS architecture, which allows easy and seamless integration and test of services. The agile approach will thus serve as a framework for the micro-management of the delivery of the value propositions foreseen in this document.

## 8.2 User Stories in Agile Development

User stories play a crucial role for the bottom up needs definition and the delivery of the intended user benefits. The user stories are simple narratives where the actors, their intentions and the set of actions they need to perform are identified. They provide the the developement team important context and associate tasks with the value they bring. User stories serve a number of key benefits as defined in Table 30 below.

[2] Jira, Agile development Online: https://www.atlassian.com/agile/project-management/workflow

**Table 37**. User Story Benefits and Utilisation to Support SPHERE

| User Story Benefits | User Story Utilisation and Support to SPHERE |
|---|---|
| **Stories keep the focus on the user.** A To Do list keeps the team focused on tasks that need checked off, but a collection of stories keeps the team focused on solving problems for real users | The user centric approach of the SPHERE is supported by the user stories. Task 2.4 further elaborates the findings.<br>**The final product is expected to provide direct benefits to the identified users within the studied workflows.** |
| **Stories enable collaboration.** With the end goal defined, the team can work together to decide how best to serve the user and meet that goal. | The user stories of SPHERE allow the integration of various backend services to deliver the expected benefits. Functional Input/Output definitions are made with relation to the user stories.<br>**The Digital Twin data backend serves as a consolidating data service to support the collaboration.** |
| **Stories drive creative solutions.** Stories encourage the team to think critically and creatively about how to best solve for an end goal | The user story approach has been utilised with the pilot field users and potential stakeholders.<br>**The approach serves as an innovative platform for the transition of the use of digitised processes and common digital twin configuration practices.** |
| **Stories create momentum.** With each passing story the development team enjoys a small challenges and a small win, driving momentum | The SPHERE project relies on the integration of the various background and customised tools.<br>**The agile approach, supported by a central data backend service, provides the independent progress of the capabilities, thus allowing the parallel processing and integration when applicable. Teams will have autonomy on the delivery of the story requirements and ability to use their own performance metrics.** |

The stories serve both a top down approach where high level ambitions, called initiatives are used to define the needs, as well as a bottom up approach, where free text needs can be identified and later clustered as presented in the figure [on the right]. The below figure delivers an exemplary breakdown of the use of user stories for the overarching ambition of SPHERE, broken down as a module and its user stories.

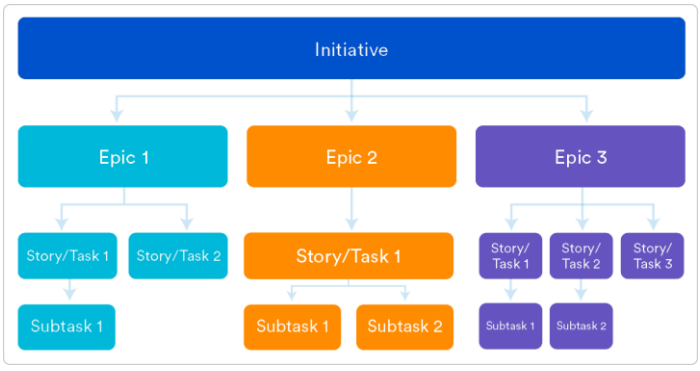



**Figure 39**. Breakdown of work in Initiatives, Epics, Tasks and Subtasks

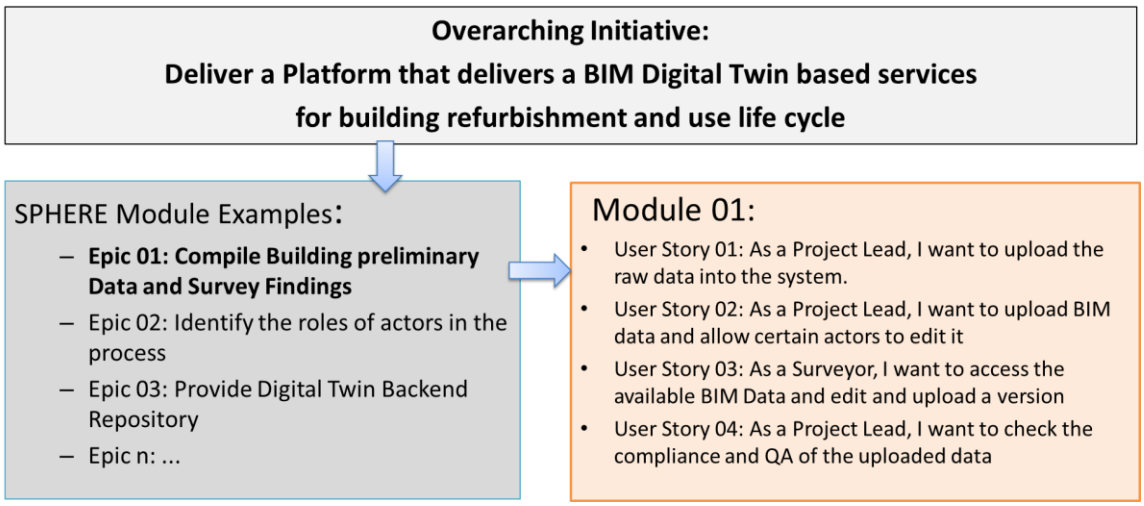



**Figure 40.** Example of an Initiative, Epic and User Story relationship

## 8.3 SPHERE Project's use of Agile Development

As a market oriented innovative product development project, SPHERE methodology and work packages are designed to serve the agile approach. The core steps of learning, building and measuring of the delivered results, are carried out in the respected work packages in an iterative approach .As figure 41 showcases, the initial phase of needs assessment and definitions, which have been carried in relation to the Pilot stakeholders' and market needs, will be further designed, developed and delivered. The continuous iteration of the project will provide an efficient and beneficial final SPHERE platform.

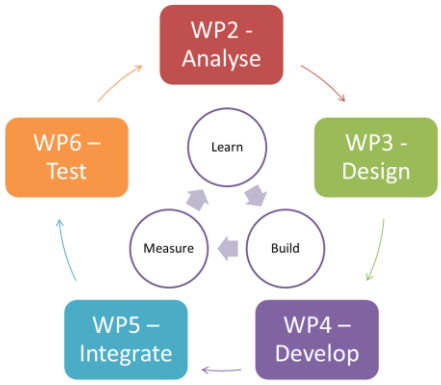



**Figure 41**. Work-Package relationships

**Benefits of the Agile Integration Approach Existing Services and Technologies**

The related software capabilities of all partners are defined that allow the exploitation of previously tested and utilised functionalities to be integrated into the workflows of SPHERE and strengthen the value proposition of the platform. The collected background information includes:

- The known barriers / pains and how the solutions propose to relieve them (Deliverable 2.1)
- The functions related to the renovation and construction process and SPHERE platform (Chapter
- The input/output data structures (Work-package 3 based on information flows in Chapter 6)
- The accessibility and architecture (Work-package 3)

This chapter forms a section of the Software Functional Specifications, identifying the existing situation and allowing the SPHERE platform to build on top the assets. The works will be moved forward in the XWIKI SPHERE platform (described in section 3.12).

# 9 Conclusions

## 9.1 Summary of Achievements

At a technical level the works in this deliverable have achieved the purposes as set out in the project's Description of Activities (DoA). To provide for the user stories for the SPHERE platform including new Integrated Design and Delivery Service (IDDS) user stories (Chapter 5), the related features to create full use cases (Appendices A and B), and the relations to the demonstration pilot company needs to start the user scenarios. Also a full listing of platform needs in terms of software modules and sub-modules has been delivered (Chapter 4). Creating the **platform functionality requirements** (chapter 4), the more detailed **user requirements** based on the user stories (Chapter 5), as well as the information flow requirements based on the piloting activities (Chapter 6).

The achievements also include the groundwork for user interfaces and user experiences, by delivering a methodology for setting user scenarios (Chapter 7). Including how different users would experience traversing through the interfaces and how different software tool interfaces could be integrated into the SPHERE platform overall interface, so as to provide for a united single service platform environment. A number of mock-ups where created for an example user scenario and described to other partners for feedbacks. Finally, the Agile Software Methodology is described (chapter 8) for the software implementation approach of the platform, in combination with the Quality Assurance Methodology and the implementation platform of the XWIKI that contains a digital version of all the information in this deliverable (described briefly in section 3.12 and in more detail in deliverable 2.4).

## 9.2 Relation to Continued Developments

The works in this report will be carried forward to establish the technical architecture of the SPHERE platform. It will help to make key decisions, including what needs to be improved within the existing software tools to be advanced to fit with the AECOO user requirements, what additional functionalities will need to be developed in the architecture for the SPHERE platform to fit with the demonstration company needs. It also helps by providing the groundwork for defining the data architecture of the platform, by having compiled a large number of needed information flows, and by starting to define specific features that components in the platform will need to have. And finally, it provides the basis for implementing an IDDS guideline sub-module, that will guide the implementation of IDDS as a collaborative practice across the building life cycle. As such, the report provides a compass for future development, in the form of a critical overview of the integrated capabilities of the platform for further development. More specific relating to further tasks in the SPHERE project has been described in section 2.5 of Chapter 2.

## 9.3 Lessons Learned

The works carried out with all 19 partners demonstrate the living practice of collaborations in a large multi-year European project. Communication and collaboration mostly through the internet, for delivery of the needs of users for a complex platform that is envisioned by the SPHERE consortium has been complicated and has required a constructive and problem-solving approach with substantial

patience in delivering meaningful insights and ideas. One of the challenges has been to break-down the development work sufficiently into smaller tasks and generate a structure for collaborations rapidly, without being overwhelmed by knowledge gaps or uncertainty, so as to deliver outputs at the right pace and right level. To this end a new approach is proposed for working on the same deliverable with such a large group, based on the idea of one or more core-groups and a wider task group. The core-groups consisting of up to 5 organisations representatives at maximum, to work on particular parts. Subsequently these are sent for review and discussed by the large group in the consortium. In this manner there is more space for specific discussions and interactions that works more effectively. This structure has been found to work well especially when the works can be broken down well and distributed easily among different core groups and wider task group.

Beyond the operational lessons learnt, also a number of new insights have come about in the deliverable works for the SPHERE project. The further study of IDDS practices from Deliverable 2.1 has led to the creation of a number of user stories that will help to integrate IDDS further in the SPHERE platform. The study of the 18 software tools by providers has led to cross-learnings for the platform consortium partners about each of the tools to be brough into the platform. The evaluation of the user requirements by the pilot partners as users has delivered lessons for the tool providers on more specific needs for their tools. And finally, the evaluation of the user interfaces and agile development practices has led to the basis for delivery in the project and provides alignment lessons for the consortium partners.

# 10 Acronyms

**Table 38.** Acronyms utilised in the SPHERE Project

| | | |
|---|---|---|
| 1 | **2D** | Second Dimension in BIM (plane) |
| 2 | **3D** | Third Dimension in BIM (volume) |
| 3 | **4D** | Fourth Dimension in BIM (Time, Scheduling, Planning) |
| 4 | **5D** | Fifth Dimension in BIM (Cost, Budget) |
| 5 | **6D** | Sixth Dimension in BIM (Sustainability) |
| 5 | **7D** | Seventh Dimension in BIM (Facilities Management, Life Cycle) |
| 6 | **8D** | Eighth Dimension in BIM (Safety & Security) |
| 7 | **9D** | Ninth Dimension in BIM (Lean Construction) |
| 8 | **AC** | Activities Table (CPIC Uniclass 2) |
| 9 | **ACE** | Architects Council of Europe |
| 10 | **ACFM** | Associació Catalana de Facility Management |
| 11 | **ACT** | American Council for Technology |
| 12 | **AD4** | Asset Data Dictionary Definition Document (Crossrail Limited) |
| 13 | **ADM** | Activity Definition Model |
| 14 | **ADMM** | Asset Data Management Manual (Highways Agency) |
| 15 | **ADQ** | Actual Digital Questions (from BIM Acronyms Dictionary) |
| 16 | **AEC** | Architecture, Engineering and Construction |
| 17 | **AECO** | Architecture, Engineering, Construction and Owner (or Owner-operated, or Operation) |
| 18 | **AEV** | Alternative Equivalent Value |
| 19 | **AGC** | Associated General Contractors (USA) |
| 20 | **AIA** | American Institute of Architects |
| 21 | **AIM** | Asset Information Model/Modelling |
| 22 | **AIMS** | Asset Information Management System (Crossrail Limited) |
| 23 | **AIR** | Asset Information Requirements |
| 24 | **ALM** | Asset Lifecycle Management |
| 25 | **ALM** | Application Lifecycle Management |
| 26 | **AM** | Asset Management |
| 27 | **AMF** | Asset Management Framework |

| | | |
|---|---|---|
| 28 | **AMO** | Asset Management Office (Highways Agency) |
| 29 | **AMP** | Agreed Maximum Price |
| 30 | **AMR** | Automatic Meter Reading |
| 31 | **APCE** | Associació de Promotors i Constructors d'Edificis de Catalunya |
| 32 | **API** | Application Programming Interface |
| 33 | **APM** | Association for Project Management |
| 34 | **APPs** | Applications |
| 35 | **ASHRAE** | American Society of Heating Refrigerating and Air-Conditioning Engineers |
| 36 | **AR** | Augmented Reality |
| 37 | **AS** | Appraisal of Service |
| 38 | **ASP** | Application Service Provider |
| 39 | **ATTR** | Average Time to Repair (see MTTR) |
| 40 | **Avanti** | (UK Government sponsored to assist collaboration) |
| 41 | **B&ES** | Building and Engineering Services Association (formerly, till 2012, known as HVCA). (See BESA) |
| 42 | **BACS** | Building Automation and Control System |
| 43 | **BAS** | Building Automation System |
| 44 | **BCF** | BIM Collaboration Format |
| 45 | **BCHS** | Barcode Housing System |
| 46 | **bcXML** | Building and Construction eXtensible mark-up Language |
| 47 | **BDS** | Building Description System |
| 48 | **BEIF** | Built Environment Information Fabric |
| 49 | **BEIS** | Business, Energy and Industrial Strategy |
| 50 | **BEM** | Building Energy Management |
| 51 | **BEMS** | Building Energy Management System |
| 52 | **BEP** | BIM Execution Plan |
| 53 | **BEP** | Building Energy Performance |
| 54 | **BERR** | Business, Enterprise and Regulatory Reform |
| 55 | **BES** | Building Energy Simulation |
| 56 | **BESA** | Building Engineering Services Association (See B&ES) |
| 57 | **BIM** | Building Information Model/Modelling/Management |
| 58 | **BIM(M)** | Building Information Modelling and Management |

| | | |
|---|---|---|
| 59 | **BIS** | Business, Innovation and Skills (See BEIS) |
| 60 | **BLIS** | Building Lifecycle Interoperable Software |
| 61 | **BLPU** | Basic Land and Property Unit |
| 62 | **BMS** | Building Management System |
| 63 | **BMS** | Battery Management System |
| 64 | **BOM** | Building Office Manager |
| 65 | **BOM's** | Building Object Models |
| 66 | **BOOT** | Build-own-operate-transfer (See BOT) |
| 67 | **BOQ** | Bill of Quantities (See BOQ) |
| 68 | **BOT** | Build-Operate Transfer (See BOOT) |
| 69 | **BPEP** | BIM Project Execution Plan |
| 70 | **BPI** | Building Performance Indicator |
| 71 | **BPIC** | Building Project Information Committee |
| 72 | **BPMN** | Business Process Model and Notation |
| 73 | **BQ** | Bill of Quantities (See BOQ) |
| 74 | **BQBS** | Bill of Quantities (or BQ) Breakdown Structure |
| 75 | **BRE** | Building Research Establishment |
| 76 | **BREEAM** | Building Research Establishment Environmental Assessment Method |
| 77 | **BRep** | Boundary Representation |
| 78 | **BrIM** | Bridge Information Model |
| 79 | **BS** | British Standard |
| 80 | **BSA** | Building Smart Alliance |
| 81 | **BSD** | Building Systems Design |
| 82 | **bSDD** | buildingSMART Data Dictionary |
| 83 | **BSI** | British Standards Institute |
| 84 | **BSI** | Building Smart International |
| 85 | **BSIM** | Building Services Information Model (See BIM) |
| 86 | **BSRIA** | Building Services Research and Information Association |
| 87 | **CA** | Contract Administrator |
| 88 | **CAATEEB** | Col·legi de'Aparelladors, Arquitectes Tècnics i Enginyers d'Edificació de Catalunya |
| 89 | **CAD** | Computer-Aided Design |

| | | |
|---|---|---|
| 90 | **CADD** | Computer-Aided Design and Drafting |
| 91 | **CAFM** | Computer-Aided Facility Management |
| 92 | **CAM** | Computer Aided Manufacture |
| 93 | **CAPex** | Capital Expenditure |
| 94 | **CAR** | Collection, Assessment and Response |
| 95 | **CASBEE** | Comprehensive Assessment System for Building Environmental Efficiency |
| 96 | **CATIA** | Computer Aided Three-dimensional Interactive Application |
| 97 | **CAWS** | Common Arrangement of Work Sections |
| 98 | **CBC** | Construction Blockchain Consortium |
| 99 | **CBS** | Cost Breakdown Structure |
| 100 | **CCIP** | Contractor Controller Insurance Program |
| 101 | **CCMS** | Construction Coordination Management Services |
| 102 | **CCOs** | Contract Change Orders |
| 103 | **CD** | Compact Disc |
| 104 | **CDE** | Common Data Environment |
| 105 | **CDF** | Common Data Format |
| 106 | **CDM** | Construction (Design and Management ) Regulations |
| 107 | **CDPA** | Copyright, Designs and Patent Act |
| 108 | **CE** | Construction Excellence |
| 109 | **CEC** | Commission for Environmental Cooperation |
| 110 | **CECE** | Committee for European Construction Equipment |
| 111 | **CEN** | European Committee for Stantardisation |
| 112 | **CEO** | Chief Executive Officer |
| 113 | **CERL** | Construction Engineering Research Laboratory (USACE) |
| 114 | **CFC** | Chlorofluorocarbon |
| 115 | **CFD** | Computational Fluid Dynamics |
| 116 | **CFR** | Central Facilities Repository |
| 117 | **CFRP** | Carbon Fiber Reinforcement Polymer |
| 118 | **C/I** | Civils/Infrastructure |
| 119 | **CI** | Configuration Item |
| 120 | **CI** | Continuous Improvement (the same as CIP and CPI) |

| | | |
|---|---|---|
| 121 | **CIAT** | Chartered Institute of Architectural Technologists |
| 122 | **CIB** | International Council for Research and Innovation in Building and Construction (Ant. Conseil International du Bâtiment) |
| 123 | **CIBSE** | Chartered Institution of Building Services Engineers |
| 124 | **CIC** | Construction Industry Council |
| 125 | **CIFE** | Center for Integrated Facility Engineering (Stanford University) |
| 126 | **CIM** | City Information Modelling |
| 127 | **CIOB** | The Chartered Institute of Building |
| 128 | **CIP** | Continuous Improvement Process |
| 129 | **CIR** | Contractor's Information Requirements |
| 130 | **CIS** | Construction Information Service |
| 131 | **CITE** | Construction Industry Trading Electronically |
| 132 | **CityGML** | City Geography Markup Language |
| 133 | **CL** | Construction Lean (see Lean Construction) |
| 134 | **CM** | Construction Manager |
| 135 | **CMa** | Construction Manager Advisor |
| 136 | **CMAA** | Construction Management Association of America |
| 137 | **CMAR** | Construction Management At Risk (the same as CMc) |
| 138 | **CMc** | Construction Manager as Constructor (the same as CMAR) |
| 139 | **CMDB** | Configuration Management Database |
| 140 | **CMM** | Capacity Maturity Model |
| 141 | **CMM** | Coordinate Measurement Machine |
| 142 | **CMMS** | Computerized Maintenance Management System |
| 143 | **CO** | Complexes Table (CPCI Uniclass 2) |
| 144 | **COAC** | Col·legi Oficial d'Arquitectes de Catalunya |
| 145 | **COBie** | Construction Operations Building information Exchange |
| 146 | **COEIC** | Col·legi Oficial d'Enginyers Industrials de Catalunya |
| 147 | **COINS** | Construction Industry Software |
| 148 | **COP** | Coefficient of Practice |
| 149 | **COP** | Coefficient of Performance |
| 150 | **COS** | Conditions of Satisfaction |
| 151 | **CPD** | Continuing Professional Development |

| | | |
|---|---|---|
| 152 | **CPI** | Coordinated Project Information |
| 153 | **CPI** | Continuous Process Improvement (the same as CIP) |
| 154 | **CPIC** | Construction Project Information Committee (also named CPI) |
| 155 | **CPIX** | Construction Project Information Xchange |
| 156 | **CPMS** | Capital Planning and Management System |
| 157 | **CPR** | Construction Progress Reporting |
| 158 | **CPS** | Cyber Physical Systems |
| 159 | **CPU** | Central Processing Unit |
| 160 | **CR** | Clash Rendition |
| 161 | **CRC** | Carbon Reduction Commitment |
| 162 | **CRL** | Crossrail Limited |
| 163 | **CRS** | Coordinate Reference System |
| 164 | **CRV** | Capitalised Replacement Value |
| 165 | **CSA** | Coordination and Support Actions |
| 166 | **CSCW** | Computer Supported Collaborative Working |
| 167 | **CSG** | Constructive Solid Geometry |
| 168 | **CSI** | Construction Specifications Institute |
| 169 | **CTE** | Código Técnico de Edificación (Spain) |
| 170 | **CURT** | Construction Users Roundtable |
| 171 | **D** | Deliverable |
| 172 | **D2RQ** | Database to RDF Query |
| 173 | **DB – D&B** | Design-Build |
| 174 | **DB** | Documento Básico (Spain) |
| 175 | **DBB** | Design-Bid-Build |
| 176 | **DBC** | Design Build Contract |
| 177 | **DBFM** | Design-Build-Finance-Maintain |
| 178 | **DBFO** | Design, Build, Finance, Operate |
| 179 | **DBIA** | Design Build Institute of America |
| 180 | **DBMS** | Data Base Management System |
| 181 | **DDBB** | Databases |
| 182 | **DBB** | Design Bid Build |
| 183 | **DCF** | Discounted Cash Flow |

| | | |
|---|---|---|
| 184 | **DCLG** | Department for Communities and Local Government |
| 185 | **DDS** | Data Design System |
| 186 | **DFMA** | Design for Manufacturer and Assembly |
| 187 | **DfT** | Department for Transport |
| 188 | **DIUS** | Department for Innovation, Universities and Skills |
| 189 | **DL** | Description Logic |
| 190 | **DL** | Deadline |
| 191 | **DL** | Deep Learning |
| 192 | **DLT** | Distributed Ledger Technology |
| 193 | **DGNB** | Deutsche Gesellschaft für Nachhaltiges Bauen |
| 194 | **DHW** | Domestic Heat Water |
| 195 | **DMP** | Data Management Plan |
| 196 | **DMS** | Document Management System |
| 197 | **DNA** | Deoxyribonucleic acid |
| 198 | **DoA** | Description of Action |
| 199 | **DPB** | Discounted Pay-Back |
| 200 | **DPP** | Developed Constructor Proposal |
| 201 | **DRC** | Depreciated Reinstatement Cost |
| 202 | **DSM** | Design Structure Matrix |
| 203 | **DSS** | Data Security Standard |
| 204 | **DSS** | Decision Support System |
| 205 | **DT** | Digital Twin |
| 206 | **DTA** | Digital Twin Aggregate |
| 207 | **DTE** | Digital Twin Environment |
| 208 | **DTI** | Digital Twin Instance |
| 209 | **DTI** | Digital Twin Institute |
| 210 | **DTP** | Digital Twin Platform |
| 211 | **DTP** | Digital Twin Prototype |
| 212 | **DTT** | Digital Twin Technologies |
| 213 | **DTV** | Design Transfer View |
| 214 | **DU** | Dumb, Uncommunicative |
| 215 | **DXF** | Drawing eXchange Format |

| | | |
|---|---|---|
| 216 | **DXF** | DaTA eXchange Format |
| 217 | **EAB** | External Advisory Board |
| 219 | **EAM** | Enterprise Asset Management |
| 219 | **EBS** | European BIM Summit |
| 220 | **EC** | European Commission/Committee |
| 221 | **ECAS** | European Commission Authentication Service |
| 222 | **ECD** | Entorno Común de Datos |
| 223 | **ECI** | European Construction Institute |
| 224 | **ECI** | Early Contractor Involvement |
| 225 | **ECI** | Environmental Cost Indicator |
| 226 | **ECM's** | Energy Conservation Measures |
| 227 | **EDCE** | Energy Demand Calculation Engine |
| 228 | **EDI** | Electronic Data Interchange |
| 229 | **EDM** | Electronic Distance Measurement |
| 230 | **EDMS** | Electronic Distance Measurement System |
| 231 | **Ee** | Elements Table (CPIC Uniclass 2) |
| 232 | **EE** | Energy Efficiency |
| 233 | **EEAB** | External Expert Advisory Board |
| 234 | **EEB** | European Environmental Bureau |
| 235 | **EED** | Energy Efficiency Directive |
| 236 | **EEO's** | Energy Efficiency Obligations |
| 237 | **EER** | Energy Efficiency Ratio |
| 238 | **EF** | Environmental Footprint |
| 239 | **EIF** | European Interoperability Framework |
| 240 | **EIR** | Employer's Information Requirements |
| 241 | **ELCD** | European Reference Life Cycle Database |
| 242 | **ELSC** | Enterprise Leadership Steering Committee |
| 243 | **EMS** | Energy Management System |
| 244 | **En** | Entities Table (CPIC Unicalss 2) |
| 245 | **EN** | EuroNorm |
| 246 | **EOL** | End of Life |
| 247 | **EOTA** | European Organisation for Technical Approvals |

| | | |
|---|---|---|
| 248 | **EP** | European Parliament |
| 249 | **EPBD** | Energy Performance of Buildings Directive |
| 250 | **EPC** | Energy Performance Contract |
| 251 | **EPC** | Energy Performance Certificate |
| 252 | **EPPM** | Engineering, Project, and Production Management |
| 253 | **EQM** | European Quality Mark |
| 254 | **ER** | Exchange Requirements |
| 255 | **ERDC** | Engineering Research and Development Center |
| 256 | **ERP** | Enterprise Resource Planning |
| 257 | **ESCO** | Energy Service Company |
| 258 | **ESR** | Evaluation Summary Report |
| 259 | **ESEER** | European Seasonal Energy Efficiency Ratio |
| 260 | **ETC** | Engineering and Technology Board |
| 261 | **ETCP** | European Construction Technology Platform |
| 262 | **ETL** | Extract, Transform and Load |
| 263 | **ETPIS** | European Technology Platform on Industrial Safety |
| 264 | **ETSI** | European Telecommunication Standards Institute |
| 265 | **EUI** | Energy Use Intensity |
| 266 | **EUPPD** | European Union Public Procurement Directive |
| 267 | **EUQ** | Element Unit Quantity |
| 268 | **EUR** | Element Unit Rate |
| 269 | **EVA** | Earned Value Analysis |
| 270 | **EVO** | Efficiency Valuation Organization |
| 271 | **EWP** | Early Works Packages |
| 272 | **FAIR** | Findable, Accessible, Interoperable, Reusable |
| 273 | **FCI** | Facilities Condition Index |
| 274 | **FCI** | Function Condition Indexation |
| 275 | **FEE** | Fabric Energy Efficiency |
| 276 | **FET** | The field-effect transistor |
| 277 | **FFE** | Furniture, Fitting and Equipment |
| 278 | **FFL** | Finished Floor Level |
| 279 | **FFP** | Fitness for Purpose |

| | | |
|---|---|---|
| 280 | **FIEC** | European Construction Industry Federation |
| 281 | **FIM** | Facilities Information Model |
| 282 | **FM** | Facility/ies Management |
| 283 | **FMA** | Facilities Management Association |
| 284 | **FMI** | Facilities Maintenance Indexation |
| 285 | **FMP** | Forward Maintenance Plans (or programme) |
| 286 | **FOAF** | Friend of a Friend |
| 287 | **FRI** | Function Re-investment Indexation |
| 288 | **FRS** | Factory Replication |
| 289 | **FRS** | Front Running Simulation |
| 290 | **FRS** | First Run Studies |
| 291 | **FTI** | Fast Track to Innovation |
| 292 | **FTP** | File Transfer Protocol |
| 293 | **GA** | Grant Agreement |
| 294 | **GBCE** | Green Building Council España |
| 295 | **GBXML** | Green Building Extensible Modelling Language |
| 296 | **GCCB** | Government Construction Client Group |
| 297 | **GCS** | Government Construction Strategy |
| 298 | **GDL** | Geometric Description Language |
| 299 | **GDPR** | General Data Protection Regulation |
| 300 | **GEA** | Gross External Area |
| 301 | **GHG** | Greenhouse Gas |
| 302 | **GC** | General Contractor |
| 303 | **GCS** | Government Construction Strategy |
| 304 | **GHG** | Green House Gases |
| 305 | **GIA** | Gross Internal Area |
| 306 | **GIFA** | Gross Internal Floor Area |
| 307 | **GIS** | Geographical Information System |
| 308 | **GML** | Geography Markup Language |
| 309 | **GMP** | Guaranteed Maximum Price |
| 310 | **GMSD** | Generative Modular Building System Design |
| 311 | **GNSS** | Global Navigation Satellite System |

| | | |
|---|---|---|
| 312 | **GPS** | Global Positioning System |
| 313 | **GRIP** | Governance for Railway Investment Projects |
| 314 | **GSA** | Government Services Administration (US) |
| 315 | **GSA** | General Services Administration |
| 316 | **GSL** | Government Soft Landings |
| 317 | **GUID** | Globally Unique Identifier |
| 318 | **GWP** | Global Warming Potential |
| 319 | **H2020** | Horizon 2020 |
| 320 | **H&S** | Health and safety |
| 321 | **HA** | Highways Agency |
| 322 | **HBI** | Human Building Interfaces |
| 323 | **HCI** | Human-Computer Interaction |
| 324 | **HCOME** | Human-Centered Ontology Engineering Methodology |
| 325 | **HCONE** | Human-Centered ONtology Engineering Environment |
| 326 | **HIL** | Hardware in the Loop |
| 327 | **HMG** | Her Majesty's Government |
| 328 | **HOAI** | Honorarordnung für Architekten und Ingenieure |
| 329 | **HSE** | Health and Safety Executive |
| 330 | **HTM** | Hypertext Markup |
| 331 | **HTM** | Human Thermal Model |
| 332 | **HTMD** | Human Thermal Model Description |
| 333 | **HTML** | Hypertext Markup Language |
| 334 | **HVAC** | Heating, Ventilation and Air Conditioning |
| 335 | **IA** | Innovation Actions |
| 336 | **IaaS** | Infrastructure as a Service |
| 337 | **IAC** | Industry Advisory Council |
| 338 | **IAI** | International Alliance for Interoperability |
| 339 | **IAM** | Institute of Asset Management |
| 340 | **IAQ** | Indoor Air Quality |
| 341 | **IBACOS** | Integrated Building and Construction Solutions |
| 342 | **IBC** | International Building Code |
| 343 | **IBC** | Institute for BIM in Canada |

| | | |
|---|---|---|
| 344 | **IBD** | Intelligent Building Data |
| 345 | **iBIM** | Integrated BIM |
| 346 | **ICC** | International Code Council |
| 347 | **ICD** | Integrated Cycle Design |
| 348 | **ICD** | Intelligent Community Design |
| 349 | **ICD** | Interface Control Documents |
| 350 | **ICE** | Institution of Civil Engineers and Innovative Contractor Engagement |
| 351 | **iCIM** | iCIM is a community resource monitoring and management platform that improves sustainability performance (see IESVE) |
| 352 | **ICIS** | International Construction Information Society |
| 353 | **ICL** | Intelligent Communities Lyfecicle |
| 354 | **ICONDA** | International CONstruction Database |
| 355 | **ICT** | Information and Communication Technologies |
| 356 | **ID** | Identification |
| 357 | **IDABC** | Interoperable Delivery of European eGovernment Services to public Administrations, Business and Citizens |
| 358 | **IDAE** | Instituto para la Diversificación y Ahorro de la Energía (Spain) |
| 359 | **IDD** | Integrated Design & Delivery |
| 360 | **IDM** | Information Delivery Manual |
| 361 | **IDDS** | Integrated Design & Delivery Solutions |
| 362 | **IDP** | Integrated Design Process |
| 363 | **IDP** | Intelligent Design Planning |
| 364 | **IDS** | Integrated Design Solutions |
| 365 | **IE** | Information Exchange |
| 366 | **IEEE** | Institute of Electrical and Electronics Engineers |
| 367 | **IEQ** | Indoor Environmental Quality |
| 368 | **IES** | Integrated Environmental Solutions |
| 369 | **IESVE** | IES Virtual Environment (IESVE) |
| 370 | **iESD** | Intelligent Energy System Designer |
| 371 | **ILCD** | Integrated Life Cycle Design |
| 372 | **IFC** | Industry Foundation Classes |
| 373 | **IFC** | Information For Construction |
| 374 | **IFD** | International Framework for Dictionaries |

| | | |
|---|---|---|
| 375 | **IFMA** | International Facilities Management Association |
| 376 | **IFoA** | Integrated Form of Agreement |
| 377 | **IG** | Irish Grid |
| 378 | **IGES** | International Graphics Exchange Standard |
| 379 | **IGLC** | International Group of Learn Construction |
| 380 | **IIOT** | Industrial Internet of Things |
| 381 | **ILCD** | International Reference Life Cycle Data System |
| 382 | **IM** | Information Modelling |
| 383 | **IMP** | Information Management Process |
| 384 | **IMU** | Inertial Measurement Unit |
| 385 | **INE** | Instituto Nacional de Estadística (Spain) |
| 386 | **IOT** | Internet of Things |
| 387 | **IP** | Intellectual Property |
| 388 | **IPC** | Integrated Project Coordinator |
| 389 | **IPCC** | Intergovernmental Panel on Climate Change |
| 390 | **IPD** | Integrated Project Delivery |
| 391 | **IPI** | Integrated Project Insurance |
| 392 | **iPIM** | iPIM is a building portfolio and asset management tool for the visualisation of key performance indicators and data. |
| 393 | **IPLV** | Integrated Part Load Value |
| 394 | **IPMVP** | International Performance Measurement and Verification Protocol |
| 385 | **IPP** | Initial Project Proposals |
| 396 | **IPP** | Inspection Point Program |
| 397 | **IPR** | Intellectual Property Rights |
| 398 | **IR** | Information Requirements |
| 399 | **IRMP** | Integrated Risk Management Plan |
| 400 | **IRR** | Internal Rate of Return |
| 401 | **IS** | International Standard |
| 402 | **iSCAN** | Intelligent Control and Analysis |
| 403 | **ISE** | The Institution of Structural Engineers |
| 404 | **ISES** | Intelligent Services For Energy-Efficient Design and Life Cycle Simulation |
| 405 | **ISG** | Implementation Support Group (Building Smart) |

| | | |
|---|---|---|
| 406 | **ISO** | International Standards Organisation |
| 407 | **IT** | Information Technology |
| 408 | **ITeC** | Institut de Tecnologia de la Construcció de Catalunya |
| 409 | **ITIL** | Information Technology Infrastructure Library |
| 410 | **ITSM** | IT Service Management |
| 411 | **IUK** | Infrastructure UK |
| 412 | **IVN** | Intelligent Virtual Network |
| 413 | **IWMS** | Integrated Workplace Management System |
| 414 | **JCT** | Joint Contract Tribunal |
| 415 | **JIB** | Joint Industry Board |
| 416 | **JIT** | Just in Time |
| 417 | **JSON** | JavaScript Object Notation |
| 418 | **JV** | Joint Venture |
| 419 | **KER** | Key Exploitable Results |
| 420 | **KET** | Key Enabling Technologies |
| 421 | **KMS** | Knowledge Management System |
| 422 | **KoM** | Kick-off Meeting |
| 423 | **KPIs** | Key Performance Indicator |
| 424 | **KRS** | Knowledge Representation Systems |
| 425 | **LADAR** | Laser Detection and Ranging |
| 426 | **LAM** | Laser Aided Modelling |
| 427 | **LAN** | Local Area Network |
| 428 | **LAS** | Look-ahead Schedule |
| 429 | **LBC** | Lean BIM Construction |
| 430 | **LBD** | Linked Building Data |
| 431 | **LC** | Lean Construction |
| 432 | **LCA** | Life Cycle Assessment |
| 433 | **LCC** | Life Cycle Contract |
| 434 | **LCC** | Life Cycle Cost |
| 435 | **LCI** | Lean Construction Institute |
| 436 | **LCI** | Life Cycle Inventory |
| 437 | **LCIA** | Life Cycle Impact Assessment |

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|---|---|---|
| 438 | **LCIE** | Life Cycle Information Exchange |
| 439 | **LCR** | Life Cycle Repairs /Replacement (Renewal) |
| 440 | **LCS** | Location Coding System (London Underground) |
| 441 | **LCT** | Life Cycle Tower |
| 442 | **LD** | Linked Data |
| 443 | **LE** | Large Enterprise |
| 444 | **LEAR** | Legal Entity Appointed Representative |
| 445 | **LEED** | Leadership in Energy and Environmental Design |
| 446 | **LIDAR** | Light Detection and ranging |
| 447 | **LIPS** | Lean in Public Sector |
| 448 | **LOD** | Level of model Detail or Level of Definition |
| 449 | **LOD** | Level of Development (in US) |
| 450 | **LOD** | Linked Open Data |
| 451 | **LOI** | Level of model Information |
| 452 | **LOIN** | Level of Information Need |
| 453 | **LPD** | Lean Project Delivery |
| 454 | **LPDS** | Lean Project Delivery System |
| 455 | **LPS** | Last Planner System |
| 456 | **LPT** | Lean Production Theory |
| 457 | **LRM** | Last Responsible Moment |
| 458 | **LRM** | Linear Referencing Method |
| 459 | **LRS** | Linear Referencing System |
| 460 | **LU** | London Underground |
| 461 | **LZC** | Low to Zero Carbon |
| 462 | **M2M** | Machine-to-Machine |
| 463 | **MC** | Main Contractor |
| 464 | **MCIA** | Material Cost Impact Analysis |
| 465 | **M&E** | Mechanical and Electrical |
| 466 | **M&O** | Maintenance and Operation |
| 467 | **MEP** | Mechanical, Electrical, Plumbing |
| 468 | **MET** | Metabolic Equivalent of Task |
| 469 | **MFA** | Material Flow Analysis |

| | | |
|---|---|---|
| 470 | **MFA** | Material Footprint Assessment |
| 471 | **MIDI** | Master Information Delivery Index |
| 472 | **MIDP** | Master Information Delivery Plan |
| 473 | **ML** | Machine Learning |
| 474 | **MMHW** | Method of Measurement for Highway Works (Highway Agency) |
| 475 | **MOPU** | Ministerio de Obras Públicas y Urbanismo (Spain) |
| 476 | **MP** | Management Plan |
| 477 | **MPA** | Multi-Party Agreement |
| 478 | **MPDT** | Model Production and Delivery Table |
| 479 | **MQC** | Model Quality Control |
| 480 | **MR** | Mixed Reality |
| 481 | **MRT** | Mean Radiant Temperature |
| 482 | **MSD** | Manpower Sources Diagram |
| 483 | **MSG** | Model Support Group (Building Smart) |
| 484 | **MSM** | Mirrored Spaces Model |
| 485 | **MTOE** | Million Tons of Oil Equivalent |
| 486 | **MTTR** | Mean Time to Resolution |
| 487 | **MVD** | Model View Definition |
| 488 | **N3** | Notation 3 |
| 489 | **N3Logic** | Notation 3 Logic |
| 490 | **NaaS** | Native as a Service |
| 491 | **NAO** | National Audit Office |
| 492 | **NBE** | Norma Básica de Edificación (Spain) |
| 493 | **NBIMS** | National BIM Standard (US) |
| 494 | **NBS** | National Building Specification |
| 495 | **NBS** | National Bureau of Standards |
| 496 | **NC** | Numerical Control |
| 497 | **NDA** | Non-Disclosure Agreement |
| 498 | **NDEA** | Non-Domestic Energy Assessment |
| 499 | **NEC** | New Engineering Contracts |
| 500 | **NEC3** | New Engineering Contract (3rd Iteration of the NEC contract) |
| 501 | **NEEDS** | New Energy Externalities Development for Sustainability |

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|---|---|---|
| 502 | **NF** | National Framework |
| 503 | **NIA** | Net Internal Area |
| 504 | **NIBS** | National Institute of Building Sciences (US) |
| 505 | **NIEM** | National Information Exchange Model |
| 506 | **NIF's** | National Interoperability Frameworks |
| 507 | **NIST** | National Institute of Standards and Technology (US) |
| 508 | **NLP** | Natural Language Processing |
| 509 | **NMS** | National Master Specification |
| 510 | **NDA** | Non-Disclosure Agreement |
| 511 | **NPC** | Net Present Cost |
| 512 | **NPV** | Net Present Value |
| 513 | **NRM** | New Rules of Measurement |
| 514 | **NS** | Net Savings |
| 515 | **NSB** | National Standards Body |
| 516 | **NST** | Negotiated Select Team |
| 517 | **NURBS** | Non-Uniform Rational B-Spline Surfaces |
| 518 | **O&M** | Operations and Maintenance |
| 519 | **OA** | Open Access |
| 520 | **OASIS** | Organisation for the Advancement of Structured Information Standards |
| 521 | **OBDA** | Ontology-Based Data Access |
| 522 | **OBS** | Organisation Breakdown Structures |
| 523 | **OCCS** | OmniClass Construction Classification System |
| 524 | **OCE** | Order of Cost Estimates |
| 525 | **OCI** | Optimised Contractor Involvement |
| 526 | **OCIP** | Owner Controller Insurance Program |
| 527 | **ODA** | Olympic Delivery Authority |
| 528 | **OEF** | Organisational Environmental Footprint |
| 529 | **OGC** | Office of Government Commerce |
| 530 | **OGC** | Open Geospatial Consortium |
| 531 | **ÖGNI** | Österreichische Gesellschaft für Nachhaltige Immobilienwirtschaft |
| 532 | **OHLE** | See OLE |
| 533 | **OIR** | Organization Information Requirement |

| | | |
|---|---|---|
| 534 | **OLE** | Overhead Line Electrification |
| 535 | **OMSI** | Operations and Maintenance Support |
| 536 | **OOP** | Objective Oriented Production |
| 537 | **OPA** | Organizational Process Assets |
| 538 | **OPex** | Operating Expenses |
| 539 | **OPex** | Operational Expenditures |
| 540 | **OPS** | Outline Procurement Strategy |
| 541 | **OR** | Operational Rating |
| 542 | **ORD** | Open Research Data |
| 543 | **OS** | Ordinance Survey |
| 544 | **OWA** | Open World Assumption |
| 545 | **OWL** | Ontology Web Language |
| 546 | **PaaS** | Platform as a Service |
| 547 | **PACE** | Property Advisers to the Civil Estate |
| 548 | **PAM** | Property Asset Management |
| 549 | **PARL** | Percentage Asset Remaining Life |
| 550 | **PAS** | Publically Available Specification |
| 551 | **PCI** | Pre-Construction Information |
| 552 | **PCI** | Payment Card Industry |
| 553 | **PC Price** | Prime Cost Price |
| 554 | **PC Sum** | Prime Cost Sum |
| 555 | **PD** | Predicted Desirable |
| 556 | **PDCA** | Plan – Do – Check – Adjust |
| 557 | **PDF** | Portable Document Format |
| 558 | **PDM** | Project Delivery Manager |
| 559 | **PDP** | Project Definition Plan |
| 560 | **PDSM** | Problem Driven Scope Management |
| 561 | **PDT** | Product Data Templates |
| 562 | **PEB** | Positive Energy Block/District |
| 563 | **PEB** | Proyectos de Ejecución BIM |
| 564 | **PEF** | Product Environmental Footprint |
| 565 | **PEP** | Project Execution Plan |

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|---|---|---|
| 566 | **PESTLE** | Political, Economic, Social, Technological, Legal, and Environmental analysis |
| 567 | **PFI** | Private Finance Initiative |
| 568 | **PHP** | Hypertext Pre-processor |
| 569 | **PIB** | Planned Inspection of Buildings |
| 570 | **PII** | Professional Indemnity Insurance |
| 571 | **PIM** | Project Information Model |
| 572 | **PIN** | Prior Indicative Notice |
| 573 | **PIP** | Project Implementation Plan |
| 574 | **PIX** | Project Information Exchange |
| 575 | **PIR** | Project Information Requirement |
| 576 | **PIT** | Project Implementation Team |
| 577 | **PLC** | Product Life Cycle |
| 578 | **PLM** | Product Lifecycle Management |
| 579 | **PM** | Person Month |
| 580 | **PMB** | Protocolo de Modelos BIM |
| 581 | **PMO** | Project Management Office |
| 582 | **PMO** | Product Modelling Ontology |
| 583 | **PMT** | Project Management Team |
| 584 | **PMV** | Predicted Mean Vote |
| 585 | **PO** | Policy Officer |
| 586 | **PO** | Project Officer |
| 587 | **POC** | Proof of Concept |
| 588 | **POE** | Post Occupancy Evaluation |
| 589 | **POS** | Proof of Stake |
| 590 | **POW** | Proof of Work |
| 591 | **PP** | Phases Table (CPIC Uniclass 2) |
| 592 | **PPA** | Public Purchase Agreement |
| 593 | **PPC** | Project Partnering Contracts |
| 594 | **PPC** | Percent Plan Complete |
| 595 | **PPD** | Predicted Percentage of Dissatisfied |
| 596 | **PPM** | Planned Preventive Maintenance |

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|---|---|---|
| 597 | **PQQ** | Pre-Qualification Questionnaire |
| 598 | **Pr** | Products Table (CPIC Unicalss 2) |
| 599 | **PSCD** | Public Sector Construction Database |
| 600 | **PSRL** | Product Semantics Representation Language |
| 601 | **PU** | Predicted Undesirable |
| 602 | **P&ID** | Piping and Instrumentation Diagram |
| 603 | **P&CM** | Project and Construction Management |
| 604 | **PV** | Present Value |
| 605 | **PV** | Photovoltaics |
| 606 | **QA** | Quality Assurance |
| 607 | **Q&A** | Questions and Answers |
| 608 | **QL** | Quality Level |
| 609 | **QoS** | Quality of Service |
| 610 | **QS** | Quantity Surveyor |
| 611 | **QTO** | Quantity Take Off |
| 612 | **R&D** | Research and Development |
| 613 | **RACI** | Responsible, Accountable, Consulted and Informed |
| 614 | **RAG** | Red, Amber, Green |
| 615 | **RAM** | Random Access Memory |
| 616 | **RCA** | Root Cause Analysis |
| 617 | **R2RML** | RDB to RDF Mapping Language |
| 618 | **RCM** | Reliability Centred Maintenance |
| 619 | **RDF** | Resource Description Framework |
| 620 | **RFDa** | Resource Description Framework in Attributes |
| 621 | **RDFS** | RDF Schema |
| 622 | **RDS** | Room Data Sheet |
| 623 | **RDS** | Room Data Schedule |
| 624 | **RFI** | Request for Information |
| 625 | **RFID** | Radio-Frequency IDentification |
| 626 | **RFP** | Request fro Proposal |
| 627 | **RGB** | Red, Green, Blue |
| 628 | **RIA** | Regulatory Impact Assessment |

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|---|---|---|
| 629 | **RIA** | Research and Innovation Actions |
| 630 | **RIAS** | Royal Incorporation of Architects in Scotland |
| 631 | **RIBA** | Royal Institute of British Architects |
| 632 | **RICS** | Royal Institute of Chartered Surveyors |
| 633 | **RIF** | Rule Interchange Format |
| 634 | **RIT** | Room Integrity Testing |
| 635 | **RMIT** | Royal Melbourne Institute of Technology |
| 636 | **ROI** | Return of Investment |
| 637 | **RPI** | Retail Price Index |
| 638 | **RSL** | Reference Service Life |
| 639 | **RST** | Rhetorical Structure Theory |
| 640 | **RTL** | Register Transfer Level |
| 641 | **RTC** | Real Time Clock |
| 642 | **RTO** | Research Technology Organization |
| 643 | **RV** | Reference View |
| 644 | **R&D** | Research & Development |
| 645 | **R&M** | Renovation & Modernization |
| 646 | **SA** | Site Area |
| 647 | **SAL** | Security Aspect Letter |
| 648 | **SaaS** | Software as a Service |
| 649 | **SAP** | Standard Assessment Procedure |
| 650 | **SAP** | Systems, Applications, Products in Data Processing |
| 651 | **SBC** | Standard Building Tribunal |
| 652 | **SBD** | Set-Based Design |
| 653 | **SBEM** | Simplified Building Energy Method |
| 654 | **SBS** | Small Business Service |
| 655 | **SCADA** | Supervisory Control And Data Acquisition |
| 656 | **SCCS** | Supply Chain Capability Summary |
| 657 | **SCPS** | Smart, Connected Product Systems |
| 658 | **SLCA** | Social Life Cycle Assessment |
| 659 | **SDD** | System Design Description |
| 660 | **SDNF** | Steel Detailing Neutral Format |

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|---|---|---|
| 661 | **SDO** | Standards Developing Organization |
| 662 | **SDS** | Space Data Sheet |
| 663 | **SDS** | Space Data Schedule |
| 664 | **SECAP** | Sustainable Energy and Climate Action Plan |
| 665 | **SETAC** | Society of Environmental Toxicology and Chemistry |
| 666 | **SGNI** | Schweizer Gesellschaft für Nachhaltige Immobilienwirtschaft |
| 667 | **SIA** | Security Industry Authority |
| 668 | **SIL** | Safety Integrity Level |
| 669 | **SIL** | Software in the Loop |
| 670 | **SIM** | Structural Information Model |
| 671 | **SIR** | Savings to Investment Ratio |
| 672 | **SKOS** | Simple Knowledge Organization System |
| 673 | **SLA** | Service Level Agreement |
| 674 | **SME** | Small and Medium Enterprises |
| 675 | **SMP** | Standard Method and Procedure |
| 676 | **SMT** | Site Management Team |
| 677 | **SOA** | Service Oriented Architectures |
| 678 | **SOAP** | Simple Object Access Protocol |
| 679 | **Sp** | Spaces Table (CPIC Uniclass 2) |
| 680 | **SPARQL** | Simple Protocol and RDF Query Language |
| 681 | **SPie** | Specifiers' Properties information exchange |
| 682 | **SPE** | Single Purpose Entity |
| 683 | **SPF** | STEP Physical File |
| 684 | **SPFF** | STEP Physical File Format (IFC) |
| 685 | **SQL** | Structured Query Language |
| 686 | **Ss** | Systems Table (CPIC Uniclass 2) |
| 687 | **SSL** | Structural Slab Level |
| 688 | **SSL** | Secure Sockets Layer |
| 689 | **SSN** | Semantic Sensor Network |
| 690 | **STEP** | STandard for Exchange of Product Model Data |
| 691 | **STL** | Standard Tessellation Language |
| 692 | **STOs** | Specific Technical Objectives |

| | | |
|---|---|---|
| 693 | **SWOP** | Semantic Web-based Open engineering Platform |
| 694 | **SWRL** | Semantic Web Rule Language |
| 695 | **TA** | Technical Adviser |
| 696 | **TAI** | Teaching as Inquiring |
| 697 | **TBD** | To Be Defined |
| 698 | **TBM** | Tunnel Boring Machine |
| 699 | **TBM** | Temporary Benchmark |
| 700 | **TCQ** | Temps, Cost, Qualitat |
| 701 | **TER** | Target Emission Rate |
| 702 | **TIDP** | Task Information Delivery Plan |
| 703 | **TILT** | Transfer Implementation Leadership Team |
| 704 | **TL** | Tube Lines |
| 705 | **TLS** | Terrestrial Laser Scanner |
| 706 | **TOC** | Table of Contents |
| 707 | **TOID** | Topographic Identifier |
| 708 | **TPI** | Tender Price Index |
| 709 | **TPS** | Toyota Production System |
| 710 | **TRL** | Technological Readiness Level |
| 711 | **TVD** | Target Value Delivery |
| 712 | **TVD** | Target Value Design |
| 713 | **TVP** | Target Value Production |
| 714 | **UC** | Use Case |
| 715 | **UCD** | User Centred Design |
| 716 | **UCL** | University College London |
| 717 | **UD** | Unpredicted Desirable |
| 718 | **UK** | United Kingdom |
| 719 | **Umbel** | Upper Mapping and Binding Exchange Layer |
| 720 | **UML** | Unified Model/ling Language |
| 721 | **UNDP** | United Nations Development Programme |
| 722 | **UNEP** | United Nations Environment Programme |
| 723 | **Uniclass** | Unified Classification System |
| 724 | **UPRN** | Unique Property Reference Number |

| | | |
|---|---|---|
| 725 | **URI** | Unique Resource Identifier |
| 726 | **URI** | Uniform Resource Identifiers |
| 727 | **US** | United States (of America) |
| 728 | **USACE** | United States Army Corps of Engineers |
| 729 | **USGBC** | United States Green Building Council |
| 730 | **UX** | User Experience |
| 731 | **UXB** | Unexploded Bomb |
| 732 | **UU** | Unpredicted Undesirable |
| 733 | **VCMP** | Virtual Construction Management Platform |
| 734 | **V2B** | Vehicle to Building |
| 735 | **V2G** | Vehicle to Grid |
| 736 | **VC** | Virtual Call |
| 737 | **VC** | Virtual Construction |
| 738 | **VDC** | Virtual Design and Construction |
| 739 | **VDR** | Virtual Data Room |
| 740 | **VE** | Virtual Environmental |
| 741 | **VERDE** | Valoración de Eficiencia de Referencia de Edificios |
| 742 | **VFM** | Value for Money |
| 743 | **VPN** | Virtual Private Network |
| 744 | **VR** | Virtual Reality |
| 745 | **VRML** | Virtual Reality Modelling Language |
| 746 | **VSM** | Value Stream Mapping |
| 747 | **W3C** | World Wide Web Consortium |
| 748 | **WAN** | Wide Area Network |
| 749 | **WBDG** | Whole Building Design Guide |
| 750 | **WBI** | Well Building Institute |
| 751 | **WBS** | Work Breakdown Structure |
| 752 | **WGBC** | World Green Building Council |
| 753 | **WIP** | Work-in-Process |
| 754 | **WLC** | Whole Life Costing |
| 755 | **WP** | Work Package |
| 756 | **WR** | Work Results Table (CPIC Uniclass 2) |

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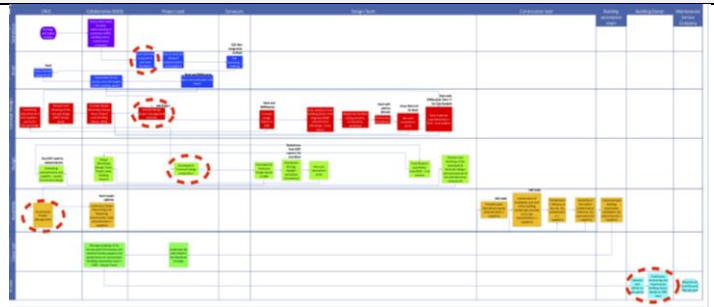
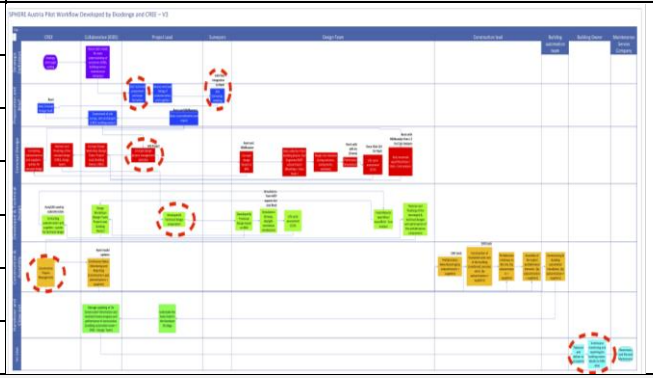
| 757 | **WRAP** | Waste & Resources Action Programme |
| 758 | **WS** | Work Results for Specifications (CPIC Uniclass 2) |
| 759 | **WTO** | World Trade Organization |
| 760 | **WWP** | Weekly Work Plan |
| 761 | **WWW** | World Wide Web |
| 762 | **XML** | eXtensible Markup Language |
| 763 | **X-REF** | Cross Reference |
| 764 | **XSD** | XML Schema Definition |
| 765 | **XSLT** | eXtensible Stylesheet Language Transformations |
| 766 | **XSP** | Cross Section Positions |
| 767 | **Zz** | CAD Table (CPIC Uniclass 2) |

# Appendix A SPHERE Module Sheet

<table>
<tr><th colspan="4">Module: I1.M1 User and Network Management</th></tr>
<tr><th>Module description:</th><th colspan="2">Used in life cycle phase:</th><th>Module use in Austria Pilot workflow:</th></tr>
<tr><td rowspan="7">Manages and assign users and roles, initiates software</td><td>Strategic definition (purple):</td><td>No</td><td rowspan="7">  </td></tr>
<tr><td>Definition and brief (Blue):</td><td>Yes</td></tr>
<tr><td>Concept Design (Red):</td><td>Yes</td></tr>
<tr><td>Dev. & Technical Design (Green):</td><td>Yes</td></tr>
<tr><td>Construction/Renovation (Yellow):</td><td>Yes</td></tr>
<tr><td>Handover & close (Dark green):</td><td>No</td></tr>
<tr><td>In Use (Turquoise):</td><td>Yes</td></tr>
<tr><th colspan="4">Sub-module Features Descriptions:</th></tr>
<tr><td colspan="2">I1.M.1.SM.1 Identify Users: (select user type from ontologies)</td><td colspan="2">I1.M.1.SM.2 Create Project & Identify Roles: (select role from predefined ontologies)</td></tr>
<tr><th>Sub-modules:</th><th>Assoc Tools:</th><th>Inputs:</th><th>Outputs:</th></tr>
<tr><td>I1.M.1.SM.1 Identify Users</td><td>Refurbify</td><td>Personal information, identification</td><td></td></tr>
<tr><td>I1.M.1.SM.2 Create Project & Identify Roles</td><td>Refurbify</td><td></td><td>Assigned roles to the created users</td></tr>
</table>

| Module: I1.M2 Processes and Workflows Management | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | Yes | |
| | Concept Design (Red): | Yes | |
| | Dev. & Technical Design (Green): | Yes | |
| | Construction/Renovation (Yellow): | Yes | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | Yes | |

| Sub-module Features Descriptions: | | | |
|---|---|---|---|
| **I1.M2.SM1 Setup and Management of Project Phases and Processes** | **I1.M2.SM2 Roles and Processes Matching** | **I1.M2.SM3 Authorisation:** | **I1.M2.SM4 IDDS Guidelines, Roles, Information Sharing:** |
| | | | |

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| I1.M2.SM1 Setup and Management of Project Phases and Processes: | Refurbify, OPT, LCCCA, CMT | | |
| I1.M2.SM2 Roles and Process Matching: | Refurbify | | |
| I1.M2.SM3 Authorisation: | Refurbify | | |

## Module: I1.M3 Common Data Environment Management

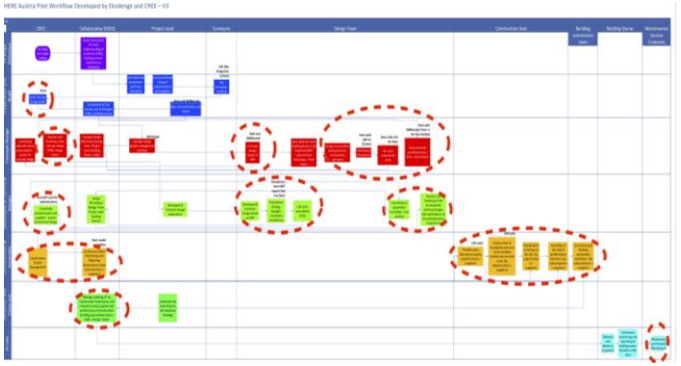
### Module description:

**Description of the module:**
The common data environment (CDE), is the single source of information used to collect, manage and disseminate documentation, the graphical model and non-graphical data for the whole project team (i.e. all project information whether created in a BIM environment or in a conventional data format). Creating this single source of information facilitates collaboration between project team members and helps avoid duplication and mistakes.

### Used in life cycle phase:

| | |
|---|---|
| Strategic definition (purple): | No |
| Definition and brief (Blue): | Yes |
| Concept Design (Red): | Yes |
| Dev. & Technical Design (Green): | Yes |
| Construction/Renovation (Yellow): | Yes |
| Handover & close (Dark green): | Yes |
| In Use (Turquoise): | Yes |

### Module use in Austria Pilot workflow:



### Sub-module Features Descriptions:

**I1.M3.SM1 Data/Document Management:**
- Add files
- Download files
- Manage document versions
- Organise documents with labels or folders
- Create relations between documents and assets
- Manage sharing of documents or specific versions of a document

**I1.M3.SM 2 Connectivity to IoT and External Live Sources:**
- Add new devices
- Review connectivity of existing devices
- Set, receive and action alerts (loss of heat supply, mechanical failure, security alarm etc.)
- Link device to object (IFC object, document)
- Visualise device location
- Comms failure notification

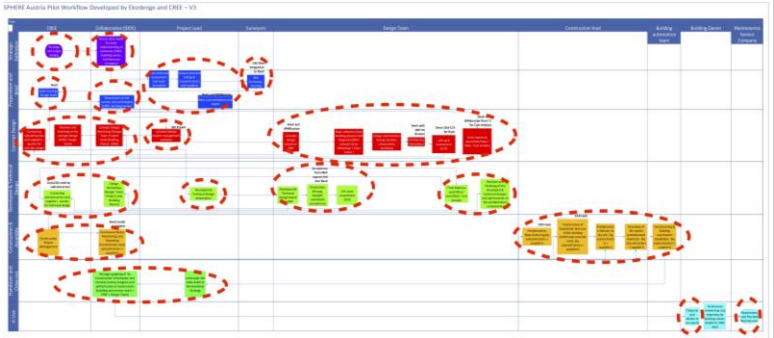
**I1.M3.SM3 Exporting/Allow Access Data:**
- Export data in different formats (xlsx, csv)
- Provide access to data through a web service (API)
- Data includes assets, requirements, specifications, properties etc.
- Protect data with a role-based security layer (you can only access what your role needs)

**I1.M3.SM4 Dynamic Data Visualisation:**
- Visualise data in dynamic tables
- Link project information (BIM data,tasks,issues) to a 3D visualisation of the BIM Model -> dynamic 3D BIM Viewer
- Provide mechanism for visualizing&analyzing large datasets from heterogeneous external source (sensor Data,simulation results, ..)

**I1.M3.SM5 Reporting:**
- Report data in a predefined document format
- Manage report templates
- Store reports documents on the file server
- Export Bill of Quantity from a selected data set
- Extract a Minutes of Meeting report
- Manage document reviews in a structured way

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I1.M3.SM1 Data/Document Management:** | Refurbify | | |
| **I1.M3.SM 2 Connectivity to IoT and External Live Sources:** | Clarity | | |

| | | | |
|---|---|---|---|
| **I1.M3.SM3 Exporting/Allow Access Data:** | Clarity | | |
| **I1.M3.SM4 Dynamic Data Visualisation:** | Clarity | | |
| **I1.M3.SM5 Reporting:** | Clarity | | |

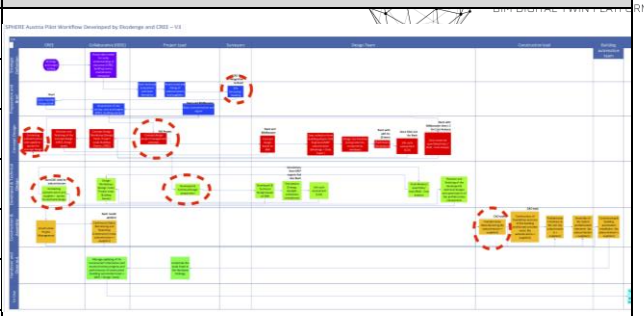
| Module: I1.M4 BIM and Object Libraries | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| | Strategic definition (purple): | Yes |  |
| | Definition and brief (Blue): | Yes | |
| | Concept Design (Red): | Yes | |
| | Dev. & Technical Design (Green): | Yes | |
| | Construction/Renovation (Yellow): | Yes | |
| | Handover & close (Dark green): | Yes | |
| | In Use (Turquoise): | Yes | |

| Sub-module Features Descriptions: | | | | |
|---|---|---|---|---|
| **I1.M4.SM1 BIM Execution Plan:**<br>• Project Information<br>• Key Project Contacts<br>• Project Goals/BIM Objectives<br>• Evaluate Partner BIM capabilities and define roles and responsibilities<br>• Technology Infrastructure Needs<br>• BIM Process Design<br>• BIM and Facility Data Requirements<br>• Model Structure<br>• BIM Information Exchanges<br>• Collaboration Procedures<br>• Model Quality Control Procedures<br>• Project Deliverables:<br>• Delivery Strategy/Contracts:<br>• Project delivery<br>• Evaluate Project success to date and revisit BEP | **I1.M4.SM2 BIM and Object Libraries:** | **I1.M4.SM3 Material Library:**<br>• Create/Update/Delete material database entries. Each entry contains below set of information<br>• Create/ update Life Cycle Inventory (LCI) entries. | **I1.M4.SM4 HVAC Library:**<br>• Providing a set of components (mathematical ) for the simulation of HVAC system for the development of a simulation model in EcosimPro:<br>• Providing a set of components for the simulation of HVAC control: | **I1.M4.SM5 Thermal and Fluid Component Libraries:**<br>• Providing a library for multicomponent fluid properties calculation to be used in HVAC components.<br>• Providing a library with thermal models of building components and base compents for the energy flow calculations: |

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I1.M4.SM1 BIM Execution Plan:** | | | |
| **I1.M4.SM2 BIM and Object Libraries:** | OPT | | |

| | | | |
|---|---|---|---|
| **I1.M4.SM3 Material Library:** | OPT | | |
| **I1.M4.SM4 HVAC Library:** | EcosimPro, RobMOS | | |
| **I1.M4.SM5 Thermal and Fluid Component Libraries:** | EcosimPro, RobMOS | | |

## Module: I1.M5 Procurement and Contracting

| Module description: | Used in life cycle phase: | | Module use in Austria Pilot workflow: |
|---|---|---|---|
| | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | Yes | |
| | Concept Design (Red): | Yes | |
| | Dev. & Technical Design (Green): | Yes | |
| | Construction/Renovation (Yellow): | Yes | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | No | |

### Sub-module Features Descriptions:

**I1.M5.SM1 Tendering Functionalities:**

*Based on the previous reports( brief and strategic definition, early concept design draft, basic cost estimation reports) find a suitable design team-company-member:*

- Review documents from previous similar projects
- Assess other concept designs and prioritise
- Access cost estimation tool
- Review contract templates for suitability
- Complete and issue tendering docs from suite of templates

*Seeking specialists using the BIM based design needs, simulation and LCA assessment:*

- Identify potential specialists
- Contact potential specialists

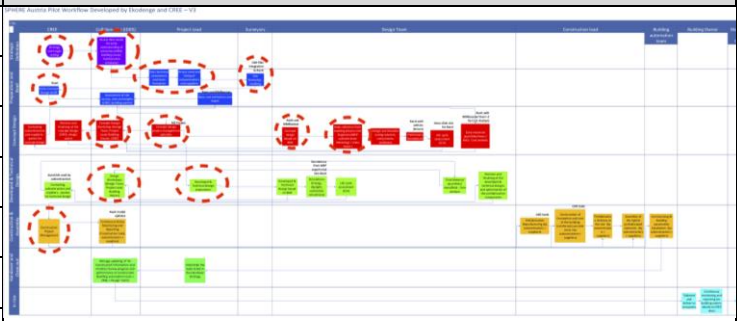
**I1.M5.SM2 Smart Contracts, Block chain**

*If desired, use the smart contract between the parties*

- Blockchain integration tbc
- Access “smart” contracts and doc via contracts module
- Digital signature
- Lock contracts within the platform and append to digital entity

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I1.M5.SM1 Tendering Functionalities:** | Refubify | | |
| **I1.M5.SM2 Smart Contracts, Block chain:** | | | |

## Module: I2.M1 Brief and Target Setting

| Module description: | Used in life cycle phase: | | Module use in Austria Pilot workflow: |
|---|---|---|---|
| Designated form including KPIs and responsibilities. Using the existing KPI databases, setting targets for the project, identifying the follow-up/monitoring need. | Strategic definition (purple): | Yes |  |
| | Definition and brief (Blue): | Yes | |
| | Concept Design (Red): | Yes | |
| | Dev. & Technical Design (Green): | Yes | |
| | Construction/Renovation (Yellow): | Yes | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | No | |

### Sub-module Features Descriptions:

**I2.M1.SM1 Brief Definition:**

- Select items to be included in the project brief (selection lists)
- Generate example empty project brief with headers
- Provide deletion or addition of further items to be included in the project brief
- Enable fill-in fields to add qualitative information under project brief header
- Generate final project brief PDF
- Enable downloading and sending of project brief to other stakeholders (for example project/building owner)

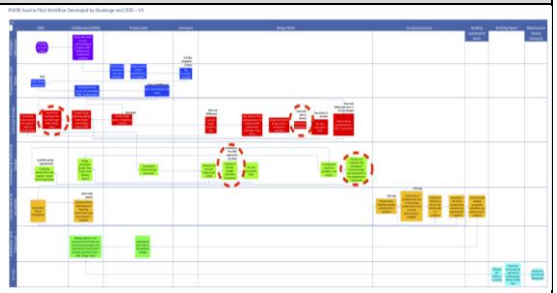
**I2.M1.SM2 Target Setting & Collaborative Management:**

- Load generated brief and unlock target template / environment
- Select targets and performance standards to track
- Select quantities of targets
- Set roles to targets for management
- Create collaboration groups
- Generate Target PDF
- Enable sending of project targets to relevant involved stakeholders

**I2.M1.SM3 ESCO Operational & Contractual Responsibilities:**

- Access energy and operational data
- Set operational responsibilities
- Set contractual responsibilities
- Create report
- Review operational responsibilities
- Review contractual responsibilities
- Export data

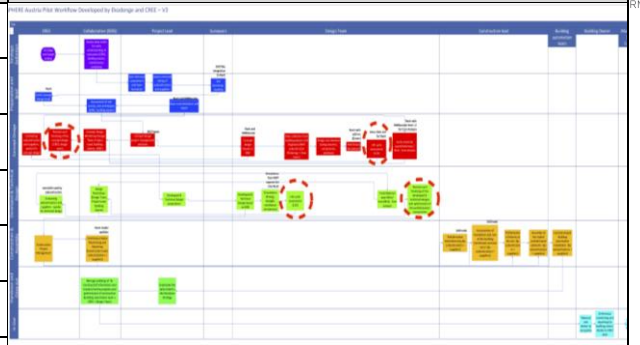
| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I2.M1.SM1 Brief Definition** | | | |
| **I2.M1.SM2 Target Setting & Collaborative Management** | | | |
| **I2.M1.SM3 ESCO Operational & Contractual Responsibilities** | En-Ms | | |

| Module: **I3.M1 Energy Modelling and Simulation** | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| Energy modelling of the asset and understanding its behaviour under certain conditions with simulations including thermal, daylight, acoustic simulations and energy assessment. | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | No | |
| | Concept Design (Red): | Yes | |
| | Dev. & Technical Design (Green): | Yes | |
| | Construction/Renovation (Yellow): | No | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | No | |

| **Sub-module Features Descriptions:** | | | | | | |
|---|---|---|---|---|---|---|
| **I3.M1.SM 1 Settings and Parameters: Temperature, indoor environment quality control (comfort):** | **I3.M1.SM 2 Targets and Metrics:** | **I3.M1.SM3 Heat load modelling:**<br>• Access the IFC file from the SPHERE Database<br>• Fill in missing data from the IFC file / additional sources<br>• Configure the Heat Load Model with parameters<br>• Run the Heat Load Model<br>• Obtain results for the model and Interpret | **I3.M1.SM4 Renovation Energy Assessment:** | **I3.M1.SM5 Energy Efficiency and Supply:**<br>• Access the project data;<br>• Extraction of Building information from BIM model;<br>• Access to meteorological data (related to the building's location);<br>• Provide the energy consumption vectors (i.e. heating, cooling, lighting, DHW). | **I3.M1.SM6 Micro-services for Energy Modelling Calibration and Validation:** | **I3.M1.SM7 Human Thermal Model:** |

| **Sub-modules:** | **Assoc Tools:** | **Inputs:** | **Outputs:** |
|---|---|---|---|
| **I3.M1.SM 1 Settings and parameters:** | RobMOS, HTM | BIM and design parameters | Energy, thermal, acoustic model of the asset. Simulation results and predicted behaviour of the asset. |
| **I3.M1.SM 2 Targets and Metrics:** | All energy tools | | |
| **I3.M1.SM3 Heat load Modelling:** | ModSCO,RobMOS, EcosimPro | | |
| **I3.M1.SM4 Renovation Energy Assessment:** | ModSCO, EcosimPro | | |

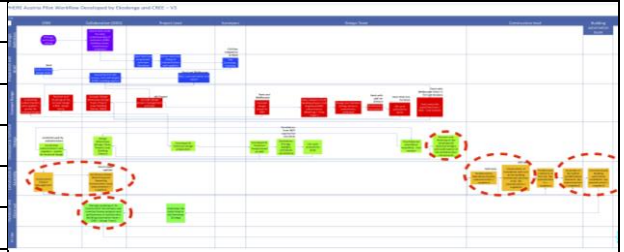
| | | | |
|---|---|---|---|
| **I3.M1.SM5 Energy Efficiency and Supply:** | iESD_E | | |
| **I3.M1.SM6 Micro-Services for Modelling:** | RobMOS | | |
| **I3.M1.SM7 Human Thermal Model:** | HTM | | |

| Module: I3.M2 Sustainability Assessment | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| The assessment capabilities, encapsulated in the digital twin platform of SPHERE, will allow the analyses of the performance within the whole life cycle of the buildings. This approach will allow the decision support to designers, construction processes as well as the occupants, including the energy consumption and waste management of the buildings as well. | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | No | |
| | Concept Design (Red): | Yes | |
| | Dev. & Technical Design (Green): | Yes | |
| | Construction/Renovation (Yellow): | No | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | No | |

**Sub-module Features Descriptions**

| I3.M2.SM1 Material Flow Management: | I3.M2.SM2 Life Cycle Impact Assessment: | I3.M2.SM3 Life Cycle Costing Analyses: | I3.M2.SM4 Circularity Assessment: | I3.M2.SM5 Water Treatment Assessment: |
|---|---|---|---|---|
| • Access the project data<br>• Extract material BoQ from the BIM file<br>• Identify the scope and functional units for the analyses (in relation to the target metrics settings)<br>• Visualise the Material flow as a whole | • Identify the reference Life Cycle Inventory<br>• Match the flows with inventory objects<br>• Visualise the matching of the material flows with inventory items<br>• Allow the selection of generic flows such as Energy grid-mix, Logistics definitions (if necessary)<br>• Allow the selection of the Impact Assessment category- ie IPCC $Co_2$ Eq tons, etc<br>• Show the results of assessment<br>• Allow benchmark/comparison of assessments - ie baseline vs proposed design, change of specific materials etc | • Identify the parameters for cost calculations<br>• Match material flows with the known costs (external software?)<br>• Provide the life cycle calculations | • Identify the metrics to be used for assessment<br>• Report on these metrics | • Access the project data;<br>• Extraction of Building information from BIM model;<br>• Access to meteorological data (related to the building's location);<br>• Access to user information |

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I3.M2.SM1 Material Flow Management** | EPESUS | | |
| **I3.M2.SM2 Life Cycle Impact Assessment:** | CMT, EPESUS | | |
| **I3.M2.SM3 Life Cycle Costing Analyses:** | LCCCA, EPESUS | | |
| **I3.M2.SM4 Circularity Assessment:** | EPESUS | | |
| **I3.M2.SM5 Water Treatment Assessment:** | iESD_W | | |

| Module: I4.M1 Blockchain Services for the Construction Processes | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | No | |
| | Concept Design (Red): | No | |
| | Dev. & Technical Design (Green): | Yes | |
| | Construction/Renovation (Yellow): | Yes | |
| | Handover & close (Dark green): | Yes | |
| | In Use (Turquoise): | No | |

**Sub-module Features Descriptions**

**I4.M1.SM1 Time Stamping/ Versioning for Digital Twin Certification:**

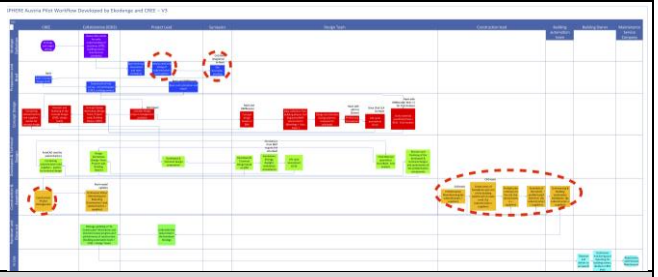
- Compilation of the below set of data for digital twin configuration
  - Responsible system user, ie. Project Configuration manager
  - Time
  - Digital Twin Standards valid at the time- achieved from the Digital Twin Management settings
  - Comments, executive summary note on the version of Digital Twin
  - Digital Twin file location (and file itself)
- All above info and only the Hash of the Digital Twin file is compiled in a an XML, JSon structure (te be defined)
- The version is digitally signed and stored for future compliance and liability validation

**I4.M1.SM2 Subcontracting Management:**

- Subcontracting party is defined in the platform and project
- Information on their scope, responsibilities stored in the system
- Scope carried out by the party defined in the system and referenced to Digital Twin / BIM subcomponents
- If a performance related obligation exists, that information and related obligations and liabilities are specified (I2.M1.SM3 3. ESCO operational & Contractual responsibilities)
- Periodic need for validation and bookkeeping specified.
- For the scope related obligations, Action (I4.M1.SM1 Time stamping/versioning for digital twin certification) carried out with reference to the subcontracting party
- In case of performance obligations, Action (I4.M1.SM2 Energy related account keeping) carried out with reference to the subcontracting party

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I4.M1.SM1 Time Stamping/ Versioning for Digital Twin Certification:** | | Monitoring data, subcontract documentation and database, progress reports, status updates | Digital Twin certification and updated certification, time stamped documents |
| **I4.M1.SM2 Subcontracting Management:** | | | |

| Module: I4.M2 Construction Operation Management |
|---|

| Module description: | Used in life cycle phase: | | Module use in Austria Pilot workflow: |
|---|---|---|---|
| | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | Yes | |
| | Concept Design (Red): | No | |
| | Dev. & Technical Design (Green): | No | |
| | Construction/Renovation (Yellow): | Yes | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | No | |

**Sub-module Features Descriptions:**

**I4.M2.SM1 Site Role/Task Management:**

- Sharing information in the right data format and quality
- Order based on BIM objects and BIM components
- During construction, continuous update of the BIM (Revit/ArchiCAD) model when something changes, create the *'As built' model*.
- The As Built Model should include all data from Architecture, MEP, Structure and should include all required data for the desired purpose.
- Define roles and responsibilities within the project
- Create tasks related to BIM object
- Assign tasks to the concerned team/worker/role
- Locate the task in the building
- Report the task status (Open, Done, Extended Deadline, Failed)
- Provide a communication channel concerning a task between the concerned users/roles

**I4.M2.SM2 Site Surveys and Inspection:**

- Sharing information in the right data format and quality
- Quality inspection of prefabrication
- Transportation inspection
- Delivery and storage on-site
- Assembly process
- Final assembly quality control

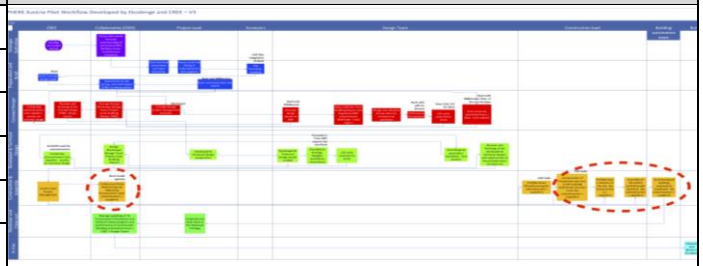
**I4.M2.SM3 Clash Detection Solving and Documenting:**

- Sharing information in the right data format and quality
- Identifying clashes, locating them on-site and in the model
- Give the task to the responsible person to solve it and document it

**I4.M2.SM4 Progress Monitoring:**

- Sharing information in the right data format and quality
- Continuous monitoring and reporting from the whole construction process.
- Handle and solve changes and delays, reporting them.

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I4.M2.SM1 Site Role/Task Management:** | Refurbify | Design/BIM documents with the identified clash, | |
| **I4.M2.SM2 Site Surveys and Inspection:** | Refurbify | | |
| **I4.M2.SM3 Clash Detection Solving and Documenting:** | | | |
| **I4.M2.SM4 Progress Monitoring:** | FLINK2GO | | |

| Module: I4.M3 Construction Document Management | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | No | |
| | Concept Design (Red): | No | |
| | Dev. & Technical Design (Green): | No | |
| | Construction/Renovation (Yellow): | Yes | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | No | |

**Sub-module Features Descriptions:**

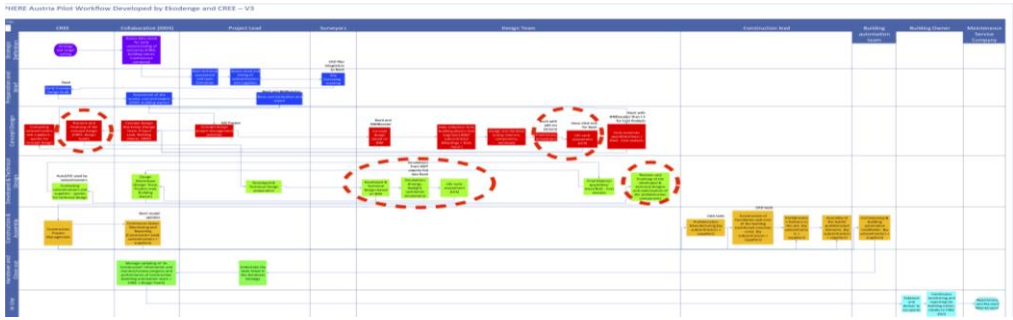
**I4.M3.SM1 Design-As Built Data Compliance:**

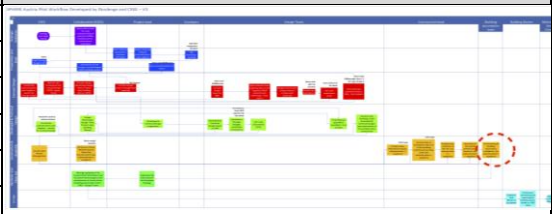
This user story is delivered by the Digital Twin Configuration management user story items

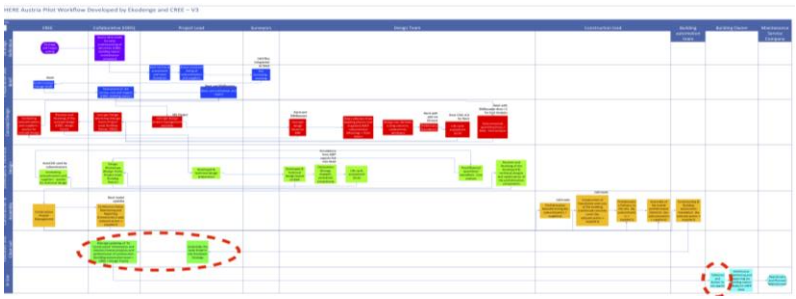
**I4.M3.SM2 Improving the Process of Change Management:**

- Identify change request
  - Owner
  - Description
  - Supportive documents (Basic BIM/CAD Drawings)
- Identify the approval needs
- Approve change
- Crete required set of documents (BIM/Dİgital Twin) for change specifications
- The rest of the user story is delivered by the Digital Twin Configuration management user story items

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I4.M3.SM1 Design-As Built Data Compliance** | | | |
| **I4.M3.SM2 Improving the Process of Change Management** | Refurbify | | |
| **I4.M3.SM3 Clash Detection** | | | |

<table>
<tr><th colspan="4">Module: I4.M4 Regulatory Compliance Check</th></tr>
<tr><th>Module description:</th><th colspan="2">Used in life cycle phase:</th><th>Module use in Austria Pilot workflow:</th></tr>
<tr><td rowspan="7"></td><td>Strategic definition (purple):</td><td>No</td><td rowspan="7">  </td></tr>
<tr><td>Definition and brief (Blue):</td><td>No</td></tr>
<tr><td>Concept Design (Red):</td><td>Yes</td></tr>
<tr><td>Dev. & Technical Design (Green):</td><td>Yes</td></tr>
<tr><td>Construction/Renovation (Yellow):</td><td>No</td></tr>
<tr><td>Handover & close (Dark green):</td><td>No</td></tr>
<tr><td>In Use (Turquoise):</td><td>No</td></tr>
<tr><th colspan="4">Sub-module Features Descriptions:</th></tr>
<tr><td colspan="4">I4.M4.SM1 Regulatory Compliance Check</td></tr>
<tr><th>Sub-modules:</th><th>Assoc Tools:</th><th>Inputs:</th><th>Outputs:</th></tr>
<tr><td>I4.M4.SM1 Regulatory Compliance Check</td><td>VCMP</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Module: I4.M5 Commissioning</th></tr>
<tr><th>Module description:</th><th colspan="2">Used in life cycle phase:</th><th>Module use in Austria Pilot workflow:</th></tr>
<tr><td rowspan="8"></td><td>Strategic definition (purple):</td><td>No</td><td rowspan="8">  </td></tr>
<tr><td>Definition and brief (Blue):</td><td>No</td></tr>
<tr><td>Concept Design (Red):</td><td>No</td></tr>
<tr><td>Dev. & Technical Design (Green):</td><td>No</td></tr>
<tr><td>Construction/Renovation (Yellow):</td><td>Yes</td></tr>
<tr><td>Handover & close (Dark green):</td><td>Yes</td></tr>
<tr><td>In Use (Turquoise):</td><td>No</td></tr>
<tr><td colspan="4">Sub-module Features Descriptions:</td></tr>
<tr><td colspan="4">I4.M5.SM1 Comparison of Energy Simulation and Real Values<br>• BUilding Energy Consumption parameters are defined<br>○ Description on scope of coverage of consumption data (whole building or zones of building)<br>▪ In case of multiple power meters, multiple entries are needed<br>• Occupancy conditions<br>▪ User numbers<br>▪ Operational practices if any (natural ventilation etc.)<br>• Energy Consumption data is compiled,<br>• Manual Process:<br>▪ The bills are entered into the platform<br>• Automated process<br>▪ Data sources are related to the above defined building zone/parameters are defined<br>▪ Automated flow of data streamlined</td></tr>
<tr><th>Sub-modules:</th><th>Assoc Tools:</th><th>Inputs:</th><th>Outputs:</th></tr>
<tr><td>I4.M5.SM1 Comparison of Energy Simulation and Real Values</td><td>RobMOS, EcosimPro</td><td></td><td></td></tr>
</table>

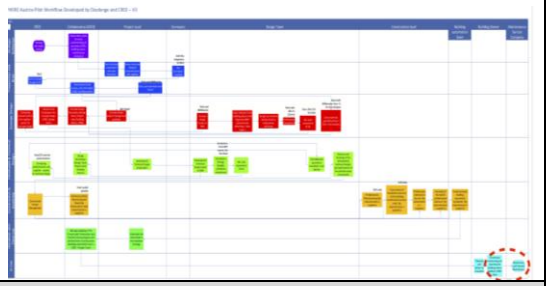
| Module: **I4.M6 Handover Management Module** | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | No | |
| | Concept Design (Red): | No | |
| | Dev. & Technical Design (Green): | No | |
| | Construction/Renovation (Yellow): | No | |
| | Handover & close (Dark green): | Yes | |
| | In Use (Turquoise): | No | |

**Sub-module Features Descriptions:**

**I4.M6.SM1 Handover Data Management:**

- Review building specific documents
- Assess for confidentiality
- Collate guarantees/contract documents
- Commence defects liability period
- Record handover acceptance
- Manage defects/handover refusal
- Collate handover information in an occupant-only environment
- Provide managed & limited access to occupant
- Link handover documents/information to the Digital Twin
- Communicate handover to project partners
- Collate O&M documents
- Collate H&S file
- Satisfy GDPR requirements

| **Sub-modules:** | **Assoc Tools:** | **Inputs:** | **Outputs:** |
|---|---|---|---|
| **I4.M6.SM1 Handover Data Management:** | Refurbify | | |

| Module: I5.M1 Facility Management | | | |
|---|---|---|---|
| **Module description:** | **Used in life cycle phase:** | | **Module use in Austria Pilot workflow:** |
| | Strategic definition (purple): | No |  |
| | Definition and brief (Blue): | No | |
| | Concept Design (Red): | No | |
| | Dev. & Technical Design (Green): | No | |
| | Construction/Renovation (Yellow): | No | |
| | Handover & close (Dark green): | No | |
| | In Use (Turquoise): | Yes | |

| Sub-module Features Descriptions: | | | |
|---|---|---|---|
| **I5.M1.SM1 Organizing Maintenance Schedules:** | **I5.M1.SM2 Decision Making for Refurbishment:**<br>• Create report<br>• Export data | **I5.M1.SM3 Building Issue Management:**<br>• Create/report issue<br>○ The issue is described, located in the 2D/3D drawing and assigned to an internal and an external responsible, if exists.<br>○ Both responsible will be notified about the issue<br>○ A picture of the issue can be attached<br>○ The issue has a deadline, which will be used to trigger various events and to give an overview about the issue status.<br>○ Status Change notification for recorded defects/issues<br>○ From assignment to completion, sent in real time<br>○ A detailed history of the issue changes is saved<br>○ Each action is traceable<br>• Overview of the site issues status for site managers and direct site responsible | **I5.M1.SM4 Data Analytics for Predictive Maintenance:** |

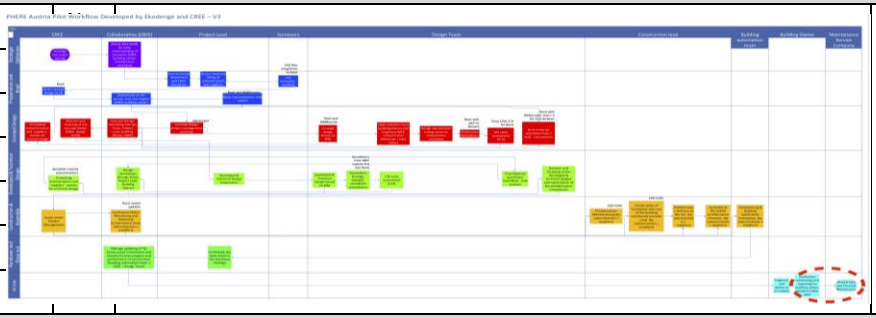
| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I5.M1.SM1 Organizing Maintenance Schedules:** | LCCCA, Refurbify | | |
| **I5.M1.SM2 Decision Making for Refurbishment:** | LCCCA, OPT, FRCT, ModSCO (only Passive) | | |
| **I5.M1.SM3 Building Issue Management:** | Refurbify | | |
| **I5.M1.SM4 Big Data Analytics for Predictive Maintenance:** | IMAN | | |

<table>
<tr><th colspan="7">Module: I5.M2 Energy Management and Performance Monitoring</th></tr>
<tr><th colspan="2">Module description:</th><th colspan="2">Used in life cycle phase:</th><th colspan="3">Module use in Austria Pilot workflow:</th></tr>
<tr><td colspan="2" rowspan="7"></td><td>Strategic definition (purple):</td><td>No</td><td colspan="3" rowspan="7">  </td></tr>
<tr><td>Definition and brief (Blue):</td><td>No</td></tr>
<tr><td>Concept Design (Red):</td><td>No</td></tr>
<tr><td>Dev. & Technical Design (Green):</td><td>No</td></tr>
<tr><td>Construction/Renovation (Yellow):</td><td>No</td></tr>
<tr><td>Handover & close (Dark green):</td><td>No</td></tr>
<tr><td>In Use (Turquoise):</td><td>Yes</td></tr>
<tr><th colspan="7">Sub-module Features Descriptions:</th></tr>
<tr>
<td>I5.M2.SM1 Data Acquisition and Status Reporting :<ul><li>Access data<ul><li>Drawings with position of installed sensors (x,z,y)</li><li>Typology of installed sensors (communication protocol, technical sheet, measured parameters, unit of measurements, …)</li><li>Declaration of conformity and take over of the whole installed system</li></ul></li><li>Privacy agreements for data sharing and their correct use (between user and SPHERE consortium)</li><li>Report of the initial calibration of the data sensors and approval according to the calibration measures plan (during data acquisition in</li></ul></td>
<td>I5.M2.SM2 Dynamic Env. Assessment and Communications:<ul><li>Energy consumption data, compiled in I4.M5.SM1 is processed into:<ul><li>Consumption of zone(s) / time period</li><li>Consumption of whole building / time period</li></ul></li><li>Set points for buildings identified as alert points of medium and high consumption (KPIs</li></ul></td>
<td>I5.M2.SM3 Energy Use Optimization: This part is exactly the same as I5.M2.SM4. There is not foreseen any specific module focused on the energy optimization.</td>
<td>I5.M2.SM4 Energy Generation Evaluation and Decision Support:<ul><li>Access the project data;</li><li>Extraction of building information from BIM model;</li><li>Access to meteorological data (related to the building’s location);</li><li>Access to user information related to:<ul><li>Technologies to be</li></ul></li></ul></td>
<td>I5.M2.SM5 Human Thermal Model Building Automation Control:</td>
<td>I5.M2.SM6 Energy Management ICT tool – ISO 50001 Decision:<ul><li>Access current and historic energy data</li><li>Review savings</li><li>Review advice</li><li>Communicate data</li><li>Communicate recommendations</li><li>Observe results of changes mad</li></ul></td>
<td>I5.M2.SM7 Reporting:<ul><li>Definition of templates for reporting. (The numbers of the templates depends on the user scenario or on KPI’s?)</li><li>Export results with a simplified content (file in PDF format) or a fully set of content for professional use (file in XLS/CSV format)</li><li>Define time-lapse for automatic reporting (daily/monthly/yearly?)</li><li>Agreement for the use of the data and definition of role and scope of data use</li></ul></td>
</tr>
</table>

| | | | | | | |
|---|---|---|---|---|---|---|
| order to assure the quality of the transmitted data)<br>• Transmission of measured data to the platform<br>○ With which timestep?<br>○ Is there, at the demo site, a temporary storage to avoid losing information due to internet fails?<br>• Definition of roles for the users:<br>○ High: professional (read, analysis, summarise)<br>○ Medium: project consortium (only reading and queries)<br>○ Low: user of the house (only reading)<br>• Duration of stored data. The data will be erased every day/month/year | from WP2 used such as kWh/m2)<br>• Related building project actors identified in relation to the alerts<br>○ Automated alarm triggers identified if any needed to a project; actor/stakeholder; Project/sub zone; KPI; Quantity; Type of alert | | evaluated (e.g. envelope part, equipment, renewable energy sources);<br>○ Criteria for the optimization (e.g. costs, energy target, etc.);<br>• Model Structure:<br>○ Consumption calculation (or access to previous energy calculation if available);<br>○ Load passive and active technologies databases;<br>○ Simulation of the passive part of the building, based on the defined criteria;<br>○ Simulation of the active part of the building based on the defined criteria;<br>○ Provide the optimal technologies | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | for passive and active technologies, as well as their impacts according to the selected criteria. | | | |

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I5.M2.SM1 Data Acquisition and Status Reporting:** | Clarity | | |
| **I5.M2.SM2 Dynamic Env. Assessment and Communications** | | | |
| **I5.M2.SM3 Energy Use Optimization:** | ModSCO, iESD_E, RobMOS, EcosimPro | | |
| **I5.M2.SM4 Energy Generation Evaluation and Decision Support** | iESD_E | | |
| **I5.M2.SM5 Human Thermal Model Building Automation Control:** | HTM | | |
| **I5.M2.SM6 Energy Management ICT tool – ISO 50001 Decision:** | En-MS | | |
| **I5.M2.SM7 Reporting:** | | | |

| Module: I5.M3 Financial Monitoring and Accounting | | |
|---|---|---|
| **Module description:** | **Used in life cycle phase:** | **Module use in Austria Pilot workflow:** |
| Especially during the operational life stage of the building this module undertakes the | Strategic definition (purple):<br>Definition and brief (Blue):<br>Concept Design (Red):<br>Dev. & Technical Design (Green):<br>Construction/Renovation (Yellow):<br>Handover & close (Dark green):<br>In Use (Turquoise): |  |

**Sub-module Features Descriptions:**

**I5.M3.SM1 + SM2 Smart Contract Based Open Ledger Bookkeeping**

- The specified financial valuation, timing and responsible party definition retrieved from the related project Management definition dataset
- Related approval procedure (or a single approval user role) specified to a user (can be handled in Project Management as well)
- Based on the Smart Contract liabilities, the financial debt equivalent of the scope of work is quantified, and the debtor and the recipient party addressed
- The related verified version from I4.SM1 SM retrieved
- The related financial transaction is made with evidence reference
- The open ledger of the project stores the transaction in the distributed framework

**I5.M3.SM3 Evidence Recording and Tracing**

- The versions stored in the project can be viewed. Related scope of the twin can be retrieved
- The related energy or similar performance stored with reference to a DT version can be retrieved
- The validation of the DT and the performance can be demanded
- The system creates stamping of the available data and compares it with the stored and signed version
  The system provides compliance of the content with the one stored at timestamp

| Sub-modules: | Assoc Tools: | Inputs: | Outputs: |
|---|---|---|---|
| **I5.M3.SM1 Construction Smart Contract Based Open Ledger Bookkeeping** | NEW TOOL | | |
| **I5.M3.SM2 Renovation Smart Contract Based Open Ledger Bookkeeping** | NEW TOOL | | |
| **I5.M3.SM3 Evidence Recording and Tracing** | NEW TOOL | | |

# Appendix B - Features of SPHERE Modules & Sub-Modules

I1.M1: User and Network Management Module

| Coding | Name | Feature from User Stories | Features from software tool providers | Notes |
|---|---|---|---|---|
| I1.M1.SM1 NEX | Identify Users | P1. Based on the needs and strategic definition, identify the users (Aus US3) – BIM Manager (Ita US2) | F1. Add new user<br>F2. Assign user to role<br>F3. Provide user overview<br>F4. Provide the ability to activate/deactivate the user<br>F5. Relate user to person/organisation in the database | Identify sounds like an automatic process or choosing users from an existing list. If by identify we mean adding / creating new users to the application, it may be more appropriate to change the wording to add / create.<br>Example: Create a user with design team role. |
| | | P2. Identify the design team users (Aus US9, US19, US27) (Ita US6, US12)<br>Assign the user (most likely to be facility manager) (Aus US36, Ita US37 ) | | |
| | | P3. (Temporarily) Defines maintenance service company user (Aus US38, Ita US39) | | |
| | | P4. Identify the users of the project manager and construction manager team that compete in the tender (Ita US20, US26, US34) Design team that complete tender (Ita US21) | | |
| | | P5. Identify the Stakeholders (Ita US22, US23, US25) | | |
| I1.M1.SM2 NEX | Create Project & Identify Roles | P1. Based on the needs and strategic definition, identify the roles (Aus US3, Ita US2) | F1. Define new role<br>F2. Assign role to user(s)<br>F3. Manage permissions per role | What does identify role mean? Is it dynamically creating new roles and permissions according to user types or assigning different permissions to predefined roles for different user types? |
| | | P2. Identify the design team roles (Aus US9, US19; Ita US6, US12, )<br>Identify the construction roles (Aus US27; Ita US26) Identify the general contractor team roles (Ita US34)<br>Assign the roles (most likely to be facility manager) (Aus US36; Ita US37) | | |
| | | P3. (Temporarily) Defines maintenance service company role (Aus US38; Ita US30) | | |
| | | P4. Tendering: Identify the roles of the project manager and construction manager team that compete in the tender (Ita US20, ) design team (Ita US21) | | |

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| | | P5. Identify Stakeholders (Ita US22, US23, US25, | | |

I1.M2: Processes and Workflow Management Module

| Coding | Name | Feature from User Stories | Features from software tool providers | Notes |
|---|---|---|---|---|
| I1.M2.SM1 NEX | Setup and Management of Project Phases and Processes | P1. Examine the predefined phases and processes (Aus US3; Ita US2) | F1. Define project phases<br>F2. Define relations between phases | We need to add more details to process management, what does project management mean in our application? is it changing the status of process (approve / reject), is it editing information, is it assigning user to the process or all of them? |
| | | P2. Process management based on design, tendering and BIM documents (Aus US27; Ita US26, US28, US29, US30, US31, US32) | | |
| I1.M2.SM2 NEX | Roles and Processes Matching | P1. Assign responsibilities to identified users and roles (Aus US3, US5, US9; Ita US2, | F1. Assign user(s) to a process/activity<br>F2. Assign role(s) to a process/activity | |
| | | P.4 Identifying responsibilities (Ita US3) | | |
| | | P2. Authorise the new users, if user is already authorised take no action (Aus US19; Ita US6, US12,) | | |
| | | P3. Roles and Process Matching based on design, tendering and BIM documents (Aus US27; Ita US23, US25, US26, US28, US30, US31, US32, US34, ) | | |
| I1.M2.SM3 NEX, VRM, ASC | Authorization | P1. Give authorisation to the users according to the identified roles and phases (Aus US3, US9, US19; Ita US2 | F1. Allow for user creation<br>F2. Allow secure access to platform | |
| | | P.5 Assign users to process (Ita US6, US12 | | |
| | | P2. Auhotisarion of the users for the software (Aus US27; Ita US23, US25, US26, US29, US30, US31, US32, US34) | F3. Manage access to platform tools | |
| | | P3. Authorisation for the new user and roles (Aus US36; Ita US37) | | |
| | | P4. (Temporarily) Authorisation for platform entry with restrictions(Aus US38; Ita US39) | | |

I1.M3: Common Data Environment/Management Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I1.M3.SM1 NEX | Data/Document Management | | F1. Add files | Again, what does management mean for our application? Adding them / removing them / changing them / grouping them / merging them / sending them?<br><br>I think it would improve readability a lot if we mention what file and data is needed for these items. |
| | | | F2. Download files | |
| | | P12. Management to the data/documents used for the selection of candidates,access to previous documentation during tendering (Ita US20, US21, | F3. Manage document versions | |
| | | P13. Management the previous BIM data and reports (design reports, LCA,LCC),access to previous documentation (Ita US22) | | |
| | | P14. Construction companies participating in the tender able to manage the previous documentation during tendering (Ita US23) | | |
| | | | F4. Organize relation between documents and assets | |
| | | | F5. Create relations between documents and assets | |
| | | | F6. Manage sharing of documents or specific version of a document | |
| | | P1. Data/document utilised by brief and target setting (Aus US1, US2, US3; Ita US1, US2 ) | | |
| | | P2 access to strategic definition and survey needs data (Aus US3; Ita US2) | | |
| | | P3 Access previous findings (Aus US4, US5, US23, US27, US28, US29; Ita US3, US5, US9, US26, US27, US28) | | |
| | | P4. Access stored documents (site survey/meeting reports, assessment of the potential subcontractors, suppliers report, strategic definition documents) for early concept design draft (Aus US6, US24, US25, US26; Ita US4, US6) | | |
| | | P5 Access to stored draft early concept design report, strategic definition phase documents (Aus US7) | | |
| | | P6. Access to stored draft early concept design report and basic cost estimation report (Aus US8, US9; Ita US4) | | |

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| | | P7. Access and use BIM documentation ,early concept report and BIM execution plan (Aus US10; Ita US7, US15, US16) | | |
| | | P8. Access and use concept design BIM models and previous documents(basic cost estimation, meeting outcomes, targets) (Aus US11, US12, ) | | |
| | | P9. Access and use concept design, BIM and simulation documentation and LCA documentation (Aus US13, US14, US15, US16, US17; Ita US8, US9, US10, US11, US12, US13, US14, US25) | | |
| | | P.10 Concept design documentation and use the workshop outcome reports, BIM based concept design technical specifications, preliminary simulation results and LCA result reports (Aus US18, US19, US20, US21, US22; Ita US17, US18, US19) | | |
| | | P11. Access to siumulation results and built-as designed data (Aus US33; Ita US34) | | |
| | | P15. Check the construction programme and previous reports and data,access to previous documentation and BIM model (Ita US29, US30, US31, US32, US33, ) | | |
| I1.M3.SM2 VRM | Connectivity to IoT and External Live Sources | P1. Set up the connectivity of automation system with the platform (Aus US33; Ita US34) | F1. Add new devices | Is connectivity integration? If it is integration, we need to identify what kind of integration it is. Through rest API? SOAP? Importing / exporting files? Creating a scheduled task to read file from a file system? |
| | | | F2. Review connectivity of existing devices | |
| | | | F3. Set, receive and action alerts | |
| | | | F4. Link device to object | |
| | | | F5. Visualize device location | |
| | | | F6. Comms failure notification | |
| I1.M3.SM3 NEX | Exporting/Allow Access/Deletion of Data and Documents | P1. Export the document in desired formats (Aus US1, US5, US23, US24, US25, US9, US19) Exporting or allowing others to access selected data which are required for the survey (Aus US2) | F1. Export data in different formats (xlxs, cvs) | |
| | | P2. Initial site assessment and parameters for BIM – if needed export the report to related parties with the desired format (Ita US3) | | |

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| | | P3. Concept design management - use the module to allow access/export data with related parties (Ita US6; Ita US12) | | |
| | | P5. Access and export the BIM based concept design technical specifications, preliminary simulation results, BoQ cositings and LCA result reports and display them (Aus US15, US17, US28; Ita US10, US11, US34) | | |
| | | P6. Export the workshop outcome reports, BIM based concept design technical specifications, preliminary simulation results and LCA result reports (Aus US18) | | |
| | | | F2. Provide access to data through a web service (API) | |
| | | | F3. Data includes assets, requirements, specifications, properties etc. | |
| | | P4. Access to previous concept design documents (Aus US13)<br>Construction companies participating in the tender access to previous BIM data and reports (design reports, LCA,LCC) (Ita US23, US25) | | |
| | | P7. Restricted access to data, only maintenance related data an d BIM for Maintenance Service Company (Aus US38; Ita US39) | | |
| | | P8. General contractor insert data and report it during starting work and provisioning of construction materials (Ita US27 | | |
| I1.M3.SM4 VRM, ASC | Dynamic Data Visualization | P1. Use dynamic table, dynamic 3D models (if needed) (Aus US22, US23, US24, US25; Ita US8, US13, US14, US15, US16) | F1. Visualize data in dynamic tables | |
| | | P2. Previous design documents will be visualised by the team (dynamic 3D models, dynamic tables etc) (Aus US20) | | |
| | | P3. Preliminary simulation results and design documents will be displayed (dynamic tables, 3D models etc.) (Aus US21) | | |
| | | P4. Display BIM data, concept design and simulation document (Ita US34) | | |
| | | P3. Use dynamic 3D BIM viewer (if needed) (Aus US10, US12, US13, US14, US16, US17, US18, US23, US24, US25, US26; Ita US7, US8, US13 US14, US15, US16 ) | F2. Link project information to 3D visualization of BIM model | |

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| | | | F3. Provide mechanism for visualizing, analyzing large amounts of data from heterogenous external source | |
| I1.M3.SM5 VRM | Reporting | P1. Report strategic brief and targets (Aus US1) Reporting functionality to export Strategic brief and send (Ita US1) | F1. Report data in a predefined document format<br>F2. Manage report templates | |
| | | P17 Based on the draft early concept report basic cost estimation (Ita US4) | | |
| | | P2. Report findings (Aus US2) : Assess data needs for early understanding of outcomes (CREE, building owner, maintenance company) | | |
| | | P3. Reporting functionality to export team and technical assessment info (Aus US3, Ita US2) | | |
| | | P4. Report findings (Aus US4): Assess need and listing of potential subcontractors and suppliers (Aus US27 | | |
| | | P5. Reports of site surveys, inspections, targets and the meeting notes (Aus US5, US17; Ita US5) | | |
| | | P6. Create draft early concept design report and basic cost report (Aus US6, US7, US10) and strategy report (Aus US9; Ita US6, US7) | | |
| | | P7. Site survey, cost and targets report (Aus US8 Assessment of site survey, cost and targets (CREE, building owner) | | |
| | | P. Expert reports (Aus US11) Prefliminary simulations (Aus US13, Ita US8) | | |
| | | P14. Life cycle assessments (LCA) report findings (Aus US14, US22; Ita US15) LCC report findings (Ita US16) | | |
| | | P15. Early materials quantities/mass / BoQ - Cost reporting (Aus US16; Ita US9) | | |
| | | P19. Developed & Technical design management and strategy report (Aus US19; Ita US12 | | |
| | | P.20 Report findings (Aus US20; Ita US13, US14,) Developed & Technical Design Design based on BIM | | |
| | | P21. Report findings (Aus US21): Simulations (energy, daylight, ventilation simulations | | |
| | | P22. Report the tendering documents and list documentation<br>(Aus US23, Ita US20) | | |
| | | P23. Report findings from final material quantities/mass/BoQ – Cost analysis (Aus US16, Ita US17) | | |
| | | P28. Report the offers content of response to the tender (Ita US24) | | |

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| | | P29. Report the anneces to the contract and certification (Ita 25) | | |
| | | P30. Report and list the construction work management document (Ita US26 ) work start up report (Ita US27) | | |
| | | P25. Construction process report (consturdtion of foundation and core of the building (Aus US29, Ita US28, US29, US30, US31, US32) Prefabrication delivery to site (Aus US30), Assembly of the hybrid prefabricated elevlemt ( Aus US31), continuour status monitoring and reporting (Aus US32, US33; Ita US33) , | | |
| | | P31. Commissioning report (Ita US34) | F2. Manage report templates | |
| | | P26. Sharing of reports between parties after design workshops (Aus US15; Ita US18) | F3. Store reports documents on the file server | |
| | | | F4. Export Bill of Quantity from a selected data set | |
| | | P16. Report the meeting notes and outcomes (Ita US3, US33) | F5. Extract a Minutes of Meeting report | |
| | | | F6. Manage document reviews in a structured way | |
| | | P.27 Sending reports (Ita US1) | | |

I1M4: BIM and Objects Library Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I1.M4.SM1 IDP, TNO | BIM Execution Plan | | Project Information | |
| | | | Key project contracts | |
| | | | Project goals/BIM objectives | |
| | | | Evaluate partner BIM capabilities and define roles and responsibilities | |
| | | | Technology infrastructure needs | |
| | | | BIM process design | |
| | | | BIM and facility data requirements | |
| | | | Model structure | |
| | | | BIM information exchanges | |
| | | | Collaboration procedures | |
| | | | Model quality control procedures | |
| | | | Project deliverables | |
| | | | Delivery strategy/contracts | |
| | | | Project delivery | |

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| | | | Evaluate project success to date and revisit BEP | |
| | | P1. BIM Execution plan (Aus US6, US10, US15, US18, US27, US29) | | |
| | | P2. Use BEP to determine priorities (Aus US29) | | |
| | | P3. Elaboration of a BEP to implement a BIM methodology (Ita US2) | | |
| | | P4 Check the BEP for basic cost estimation and report (Ita US3) | | |
| | | P5. Check the BEP for assessment of building survey, cost and targets (Ita US5) | | |
| | | P6. Check the BEP for the project management activities (Ita US6) | | |
| | | P7. Check the BIM execution plan for the concept design (Ita US7) | | |
| | | P8. Evaluate the BEP as a whole and revisit in concept design workshop (Ita US10, US11) | | |
| | | P9. Check the BEP for the site surveying and data collection (Ita US3) | | |
| | | P10. Check BIM execution plan during the construction project management (Ita US26, US27, US36) | | |
| I1.M4.SM2 TNO | BIM and Objects Libraries | P1. Create BIM model (Aut US10; Ita US7) | Configuration of the parameters of the BIM Authoring tool (work units, rules and standards of dimensioning and calculation and selection and loading of libraries). General settings (project information, project location, north configuration, geographic coordinates (longitude and latitude), elevation (A.S.L.). Grid setup and structural and architectural design module. Setting the altimetry of the virtual building (elevation and height of stories/floors). Creating properties in BIM authoring tool based on construction information. Parameter settings and insertion of BIM elements (wall, slab, column, stair, etc.). Classification of BIM elements. Verification of the design choices from an architectural and | these operations are not consequential but can take place either before or after according to the way you work with your BIM authoring tool |

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| | | | construction point of view (verification of the relationships and connections between the elements). Virtual building documentation e visualization. Export in various interoperability formats to start collaborative work. | |
| | | P2. Design size iterations based on BIM (Aut US12) | | |
| | | P3. Accessing the BIM directory and all libraries to **get the parameters** for the preliminary simulations (Aut US13, U24; Ita US8) | Conversion and revision of the BIM model into a BEM model. | In the case of Italian pilot, an add-on application is activated in the BIM authoring tools to carry out the preliminary simulations. With this add-on application active it is possible to export the BIM model with all relevant information, including thermophysical value, in gbXML, PHPP, VIP Energy format. |
| | | P4. Accessing the BIM directory and all libraries to **get the parameters** for the simulations (Aut, US21; Ita US14) | Creating properties in BIM authoring tool based on costing, structural, processing information. Export the entire model in IFC format after checking that all properties and geometry correspond to the IFC format with a specific LOD. Load IFC model in more specific simulation's software (cost, construction, structural, energy, daylight, ventilation, water reuse etc.).<br>Control and verification of the properties and classification of the BIM model. Export of the BIM model in IFC, GbXML and spreadsheet format to load in LCA e LCC app for assessment.<br>Creating properties in BIM authoring tool based on costing information. Export the information with interactive schedules that can be saved in format, Doc, Xls, Txt, Dwf, Pdf. If the xls format is used, interactive schedule can be loaded into spreadsheet applications and perform a final cost estimate through a collection of | Simulation apps (mainly energy) can also import the GBXML format.<br>In the case of Italian pilot, an the gbXML format is obtained after performing the preliminary energy simulations.<br>Calculations of final construction cost takes place through QTO (quantity takeoff) from IFC model and loaded into an 3D IFC viewer connected to an estimative metric calculation software. This app contains the database cost analysis of the works and their prices and is able to perform accounting and economic comparative tool. |
| | | P4 Check the BIM based design, object libraries and assigned materials to get input (Aut US14, US22; Ita US15, US16, US34) | | |
| | | P14. Obtain the parameters from the BIM model (Ita US17) | | |

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| | | | cost data. Export the entire model in IFC format after checking that all properties correspond to the IFC format. | |
| | | P5. BIM based design utilisation for early cost assessment (Aut US16; Ita US9) | Creating properties in BIM authoring tool based on costing information. Export the information with interactive schedules that can be saved in format, Doc, Xls, Txt, Dwf, Pdf. If the xls format is used, interactive schedule can be loaded into spreadsheet applications and perform a preliminary cost estimate through a collection of cost data. Export the entire model in IFC format after checking that all properties correspond to the IFC format. | Use an IFC viewer to extract all the information in lists and schedules directly from the model. Export the BIM Model in IFC format and load in an IFC viewer connected to an Estimative metric calculation software. |
| | | P6. Verify the BIM based on the workshop feedbacks. If not review the design and BIM (Aut US18, U26; Ita US11, US19) | Coordinate and verify the BIM model with an external IFC viewer or the same BIM authoring tool used. in this phase it is possible to clash detection between groups of elements and set verification rules to look for possible design errors | External IFC viewer as a Solibri, Trimble Connect and Navisworks etc. |
| | | P7. New objects will be added to the BIM library and BIM object libraries will be utilised for updating the BIM (Aut US20; Ita US13) | Acquisition of BIM objects from the different databases of manufacturers of materials and construction components to link them to the project file opened in the BIM creation tool and carry out a more detailed design. | Search and download BIM objects from different websites and then collect them in a folder to create a dedicated library.<br>It is also possible to search BIM objects with functionality inside the BIM authoring tool used. |
| | | P8 Access the updated data for preparing tendering documents (Aut US23) | | |
| | | P9. Export BIM data and provide it to the manufacturer (Aut US 29) | | |
| | | P10. Verify the compliance of the delivered parts with the BIM and object libraries (Aut US30) | | |
| | | P11. Updating the BIM model and material library as work progresses to produce an 'as-built' model (Aut US31, US32; Ita US33) and at the final stage (AutUS35; Ita US36) | Before (to simulate the construction process) and after during the construction phases it is possible to associate an | The update of the "as build" model takes place in base of |

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| | | | exported model in IFC format to connect this model to a project management software. Based on what is built on site, the BIM model, of the previous design phases, is analysed on the basis of a WBS and progressively updated in an "as-built". | information reported by construction surveyor. |
| | | P12. During commission and building automation installation check the updated BIM model and identify the installation location (Aut US33) | | |
| | | P13.Check the updated BIM model and identify the built elements (Ita US34) | In order to carry out the commissioning checks analyse the AS built model. | In the IFC 3D viewer, the verification rules are set to search for possible construction errors. |
| | | P14.Update the BIM Model to the final stage (Ita US36) | Updating the BIM model with all the information of handover with the BIM authoring tool used | it is possible to create a model record that contains all the information on the building as well as the geometry of the model itself as a warranty, property and maintenance manuals, training videos, etc. |
| | | | | |
| I1.M4.SM3 EKO | Material Library | P1 Using BIM object libraries to import BIM objects as the design proceed (Aus US10; Ita US7) | F1. Create/Update/Delete material database entries. Each entry contains below set of information:<br>Material name, Description, Provider(s), Web link of product, Any reference to Life cycle inventories (Yes/N0), If yes what?, Additional documents (EPD, EU Directive related documents (Reach, etc.)), BIM Object(s) (Types of details if available), Creator of entry, Date of creation | |
| | | P2. Accessing the BIM directory and all libraries to **get the parameters** for the preliminary simulations (Aus US13, US21, US24; Ita US8, US14) | F2. Create/ update Life Cycle Inventory (LCI) entries, including; Name of Inventory, Provider, Description, Number of objects, Web link, References to materials in the SPHERE database that are within the LCI | |

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| | | P3. Check the BIM based design, object libraries and assigned materials to get input (Aus US14, US22; Ita US15, US16)<br>Check the updated BIM model and identify the built elements (Ita US34, US36) | | |
| | | P4. BIM based design utilisation for early cost assessment (Aus US16, Ita US9) | | |
| | | P5. Verify the BIM based on the workshop feedbacks. If not review the design and BIM (Aus US18, US26, Ita US11, US19) | | |
| | | P6. Together with object libraries, material libraries will be used to assign materials to the BIM objects and design (Aus US20; Ita US13) | | |
| | | P7. Access the updated data for preparing tendering documents (Aus US23) | | |
| | | P8. Export BIM data and provide it to the manufacturer (Aus US28) | | |
| | | P9. Obtain the parameters from the BIM model (Ita US17) | | |
| | | P10. Updating the BIM model and material library as work progresses to produce an 'As-Built' model (Ita US33) | | |
| I1.M4.SM4 EAI | HVAC Library | | F1. Providing a set of components for the simulation of HVAC system for the development of a simulation model in EcosimPro | HVAC library is a set of elements for the simulation of HVAC systems in EcosimPro. It cannot be used directly from SPHERE platform because it requires EcosimPro simulation platform to work |
| | | | F2. Proving a set of components for the simulation of HVAC control | |
| | | P1. Using HVAC object libraries to import HVAC objects as the design proceed (Aus US10; Ita US7) | F3. HVAC libraries are simulation libraries, therefore they do not import BIM entities. However, a functionality will be provided to map IFC entities to objects in the HVAC libraries and import their parameters. | EAI will provide F3 inside EcosimPro. It is a functionality independent from HVAC module. Mapping and parameter importation is dependent of the target tool so in our opinion cannot be a generic tool. |
| | | P2. Accessing the BIM directory and all libraries to **get the parameters** for the preliminary simulations (Aus US13, US21, US 24; Ita US8, US14) | F1. Providing a set of components for the simulation of HVAC system for the development of a simulation model in EcosimPro | F1 and F2 the elements to carry out simulations of HVAC system. F3 addresses IFC entitities mapping to HVAC object and |

| | | | | |
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| | | | F2. Proving a set of components for the simulation of HVAC control<br>F3. Importation of HVAC equipment parameters to EcosimPro simulation tool | importation of parameters. All the functionalities are provided inside EcosimPro platform. |
| | | P10. BIM based design utilization for early cost assessment (Ita US9) | | Information from simulation can be used as input for cost assessment tools but the module do not cover cost assessment itself.<br><br>DONE IN SPHERE |
| | | P3. Check the BIM based design, object libraries and assigned materials to get input (Aus US14, US21; Ita US15, US16, US34) ) | | THIS IS NICE TO HAVE BUT DIFFICULT |
| | | P11. Obtain the parameters from the BIM model (Ita US17) | | Not addressed within the module. To be analysed to what extend F3 can provide a limited checking<br><br>DONE IN ECOSIMPRO |
| | | P4. Early materials quantities: BIM based design utilisation for early cost assessment (Aus US16) | | |
| | | P5 Verify the BIM based on the workshop feedbacks. If not review the design and BIM (Aus US18, US26; Ita US11, US19) | | |
| | | P6. As the HVAC system being designed, HVAC objects from the libraries will be used to update BIM model (Aus US20; Ita US13) | | To be analysed. To do that, it should be clearly defined what information to update and with which structure. If the scope is too wide may not be possible to do it in the framework of SPHERE project. |
| | | P7. Access the updated data for preparing tendering documents (Aus US23) | | Out of the module scope. |

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| | | P8. Commissioning and Building automation installation: check the updated BIM model and identify the installation location (Aus US33) | | Should be other module the one providing this service. |
| | | P9. Reactionary and Planned Maintenance: BIM model access to the maintenance situation (Aus US38; Ita US39) | | This is not related to simulation. Other module should provide this. |
| | | P12. Updating the BIM model and HVAC libraries as work progresses to produce an 'As built' model (Ita US33) | | |
| | | P13. Update the HVAC Library to the final stage (Ita 36) | | |
| I1.M4.SM5 EAI | Thermal and Fluid Component Libraries | | F1. Proving a library for multicomponent fluid properties calculation to be used in HVAC components | Similarly to HVAC module, this module requires simulation platform to work and it is meant to provide the fluid properties necessary for the HVAC library and elements to simulate the building. |
| | | | F2. Providing a library with thermal models of building components and base components for the energy flow calculations | |
| | | P1. Using thermal and fluid component libraries as the concept HVAC design proceed (Aus US10; Ita US7) | F1, F2 and HVAC module. | |
| | | P2. Accessing the BIM directory and all libraries to **get the parameters** for the preliminary simulations (Aus US13, US21, US24; Ita US8, US14) | F3. Importation of geometry, special relations, geographic information, material quantities and properties to EcosimPro simulation tool provided by a specific module in EcosimPro, not I1.M4.SM5. | Inside EcosimPro. |
| | | P3. Check the BIM based design, object libraries and assigned materials to get input (Aus US14, US22; Ita US15, US16, US34) | | Not addressed within the module. To be analysed to what extend F3 can provide a limited checking |
| | | P4. BIM based design utilisation for early cost assessment (Aus US16; Ita US9) | | Information from simulation can be used as input for cost assessment tools but the module do not cover cost assessment itself. |
| | | P5. Verify the BIM based on the workshop feedbacks. If not review the design and BIM (Aus US18, US26; Ita US11, US19) | F1, F2 and HVAC module. | |
| | | P6. Together with HVAC and pipe infrastructure design, this library will be used to assign materials align with the desired properties (Aus US20; Ita US13) | | |

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| | | P7. Access the updated data for preparing tendering documents (Aus US23) | | P9 to be analysed to what extent the BIM can be modified to introduce modifications from the simulation model |
| | | P8. Obtain the parameters from the BIM model (Ita US17) | | |
| | | P9. Updating the BIM model and thermal and fluid component libraries as work progresses to produce an 'As built' model (Ita US33) | | |

I1.M5: Procurement and Contracting Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I1.M5.SM1 VRM | Tendering Functionalities | | F1. Review documents from previous similar projects | |
| | | | F2. Assess other concept designs and prioritize | |
| | | | F3. Access cost estimation tool | |
| | | | F4. Review contract templates for suitability | |
| | | | F5. Complete and issue tendering docs from suite of templates | |
| | | | F6. Identify potential specialists | |
| | | | F7. Contract potential specialists | |
| | | P1. Site Surveying: Make the contract with surveyors / auditors acc. to required procurement process and identified responsibilities (Aus US5; Ita US3) | | |
| | | P2. Concept design project management activities: Based on the previous reports( brief and strategic definition, early concept design draft, basic cost estimation reports) find a suitable design team-company-member (Aus US9; Ita US6) | | Is finding a suitable design team-company-member an automatic process? Is some kind of recommender system required? What makes a design team-company member suitable? |

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| | | P3. Contracting specialist for concept design: Seeking specialists using the BIM based design needs, simulation and LCA assessment (Aus US15) | | |
| | | P4. Based on the concept design phase reports find a suitable design team-company-member (if necessary) (Aus US19; Ita US12) | | |
| | | P5. Contacting subcontractors and suppliers:<br>Use for tendering with the tendering documentation. Find the manufacturer (Aus US23; Ita US20) | | What do we mean by contacting, sending them invitation e-mail? |
| | | P6. Starting manufacturing process (Aus US28) | | |
| | | P7. Based on the Brief , Target and Strategy find project manager and construction manager (Ita US1) | | |
| | | P8. Use for the preparation of the tender documentation for the selection of design team (Ita US21, US22) | | |
| | | P9. Use to make offers for tendering from construction companies participating in the tender (Ita US23) | | |
| | | P10. Use for comparison of the bids in the tender (Ita US24) | | |
| | | P11. Use for acceptance of the tender contract. (Ita US25) | | |
| I1.M5.SM2 EUT | Smart Contracts; Blockchain | | F1. Blockchain integration | I believe the term smart contract is misunderstood here. Smart contract is not a document, but it is a computer program that executes automatically when a condition is met. So does accessing smart contract means accessing the source code of the application within the website? |
| | | P1. Concept design project management activities: using contracting module (Aus US9; Ita US6) | F2. Access “smart” contracts and doc via contracts module | |
| | | P2. To be able to initiate detailed & technical design strategy and decisions: use contracting module (Aus US19; Ita US12) | | |
| | | P3. Contracting subcontractor and suppliers: is desired, use the smart contract between the parties (Aus US23; Ita US21) | | |
| | | P4. Tendering for project manager and construction manager: use contract module (Ita US20) Design team (Ita US21) | | |
| | | P5. Identification of the winner of the tender and signing of the contract (Ita US25) | F3. Digital signature | |
| | | | F4. Lock contracts within the platform and append to digital entity | |

I2.M1: Brief and Target Setting Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I2.M1.SM1 EKO | Brief Definition | | F1. Select items to be included in the project brief | |
| | | | F2. Generate example empty project brief with headers | |
| | | | F3. Deletion or addition of further items to be included in the project brief | |
| | | | F4. Enable fill-in fields to add qualitive information under project brief header | |
| | | | F5. Generate final project brief PDF | |
| | | | F6. Enable downloading and sending of project brief to other stakeholders | |
| | | P1. Obtain brief template and fill in details, attach files (Aus US1; Ita US1) | | |
| | | P2. Use the filled template during the definition of the needs (Aus US2) | | |
| I2.M1.SM2 EKO | Target Setting & Collaborative Management | | F1. Load generated brief and unlock target template | |
| | | P3. Define the needs and possible solution targets (Aus US4) | F2. Select targets and performance standards to track | |
| | | P1. Utilisation of target setting dashboard from baseline for identifying needs when identifying overarching objective and performance criteria (Aus US1, US2; Ita US1) | F3. Select quantities of targets | |
| | | P5. Concept design target setting (Aus US6) | | |
| | | P4. Meeting arrangement and assigning responsiblities (Aus US5; Ita US3) | F4. Set roles to targets for management | |
| | | P10 Stakeholder cooperation management and plans (Aus US27) | | |
| | | P7. Active collaboration management among the experts (Aus US11; Ita US7) management and workshop organization (US17; Ita US10) | F5. Create collaboration groups | |
| | | P2. Setting up the collaboration management and rules and guidelines for using it (Aus US3; Ita US2) | | |
| | | P8. Set up design team collaboration strategy ofr developed&technical design phase (Aus US19) | | |

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| | | P6. Set up design team collaboration strategy (Aus US9, US10; Ita US6, US12) | | |
| | | P11. Management of executive meetings for planning verification, progress and work variants and BIM model "as built" (Ita US33) | | |
| | | | F6. Generate target PDF | |
| | | P10. Management of executive meetings between the stakeholders (Ita US26, US31) | F7. Enable sending of project targets to relevant involved stakeholders | |
| | | P9. Worksop target settings and stakeholder involvement management (Aus US25; Ita US18) | | |
| I2.M1.SM3 R2M | ESCO Operational & Contractual Responsibilities | | F1. Create report | |
| | | | F2. Access energy and operational data | |
| | | | F3. Set operational responsibilities | |
| | | | F4. Set contractual responsibilities | |
| | | | F5. Review operational responsibilities | |
| | | | F6. Review contractual responsibilities | |
| | | | F7. Export Data | |

I3.M1: Energy Modelling and Simulation Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I3.M1.SM1 TNO | Settings and Parameters: Temperature, Indoor Environment Quality Control (Comfort) | P1. Preliminary simulations: After getting the parameters input these values. Adjust the settings (Aus US13) | | |
| | | P2. Check the findings, verify the simulation findings.If not review the design (Aus US18, US26; Ita US19) | | |
| | | P3. After getting the parameters input these values. Adjust the settings (Aus US21; Ita US8, US14, ) | | |
| I3.M1.SM2 TNO | Targets and Metrics | P1. Set simulation targets based on the inputs and adjust the metrics (Aus US13, US21; Ita US8, US14) | | |
| | | P2. Check the findings, verify the simulation findings.If not review the design (Aus US18, US26; Ita US11, US19) | | |
| I3.M1.SM3 | | | F1. Access the IFC file from the SPHERE database | |

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| TNO, EAI | Heat Load Modelling | | F2. Fill in missing data from the IFC file/additional sources | |
| | | | F3. Configure the heat load model with parameters | |
| | | | F4. Run the heat load model | |
| | | | F5. Obtain results for the model and interpret | |
| | | | F6. | |
| | | P1. Based on the BIM model and parameters, conduct preliminary heat load modelling (Aus US13, US21) | | |
| | | P2. Check the findings, verify the simulation findings. If not review the design (Aus US18, US26; Ita US11, US19 ) | | The five functionalities listed cover the two requirements and also the energy assessment requirements if they are written in a generic way. Instead of heat load model, simulation model. However, not sure how TNO want to address this. Similar to first request US13, US21 |
| | | P3. Based on the BIM model and parameters, conduct preliminary heat load modelling (Ita US8, US14) | | |
| I3.M1.SM4 TNO, EAI | Renovation Energy Assessment | P1. Based on the BIM model, objects and parameters, conduct preliminary energy assessment (Aus US13, US21) | | |
| | | P2. Check the findings, verify the simulation findings.If not review the design (Aus US18, US26; Ita US19) | | |
| | | P3. Check and verify the simulation results. If the project is not reviewed (Ita US11) | | |
| I3.M1.SM5 EUT | Energy Efficiency and Supply | | F1. Access the project data | |
| | | | F2. Extraction of building information from BIM model | |
| | | | F3. Access to meteorological data | |
| | | | F4. Provide the energy consumption vectors | |
| | | P1. Get the results from preliminary heat load modelling and energy assessment, conduct preliminary energy efficiency simulation (Aus US13, US21) | | |
| | | P2. Check the findings, verify the simulation findings.If not review the design (Aus US18, US26; Ita US11, US19) | | |
| I3.M1.SM6 TNO | Micro-services for Energy Modelling | P1. Use the BIMbot service for facilitate the preliminary heat and energy simulations (Aus US13, US21; Ita US8, US14) | | |

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| | Calibration and Validation | P2. Check the findings, verify the simulation findings.If not review the design (Aus US18, US26; Ita US11, US19) | | |
| I3.M1.SM7 VTT | Human Thermal Model | P1. Use the human thermal model with the preliminary heat load modelling to obtain a concept model (Aus US13, US21; Ita US8, US14) | | |
| | | P2. Check the findings, verify the simulation findings.If not review the design (Aus US18, US26; Ita US11, US19) | | |

I3.M2: Sustainability Assessment

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I3.M2.SM1 EKO | Material Flow Management | P2. Check the findings, verify the sustainability assessment findings.If not review the design (Aus US18, US26; Ita US19) | F1. Access project data | |
| | | | F2. Extract material BoQ from the BIM file | |
| | | | F3. Identify the scope and functional units for the analyses | |
| | | P1. Based on the inputs from previous tasks, form the intermediate material flow and basis of the material flow management (Aus US14) | F4. Visualize the material flows as a whole | |
| | | P3. Based on the inputs from previous tasks, form the finalised material flow and basis of the material flow management (Aus US22; Ita US15, US16) | | |
| I3.M2.SM2 EKO | Life Cycle Impact Assessment | | F1. Identify the reference Life Cycle Inventory | |
| | | | F2. Match the flows with inventory objects | |
| | | P1. Use the material flow and material libraries to get parameters, use them to complete the life cycle impact assessment (Aus US14, US22; Ita US15) | F3. Visualize the matching of the material flows with inventory items | |
| | | | F4. Allow the selection of generic flows such as Energy grid-mix, Logistics definitions | |
| | | | F5. Allow the selection of the Impact Assessment category | |
| | | P2. Check the findings, verify the sustainability assessment findings.If not review the design (Aus US18, US 26; Ita US19) | F6. Show the result of assessment | |
| | | | F7. Allow benchmark/comparison of assessments | |
| I3.M2.SM3 | | | F1. Identify the parameters for cost calculations | |

| | | | | |
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| EKO | Life Cycle Costing Analyses | P1. Use the material flow and material libraries to get parameters, use them to complete the life cycle costing analyses (Aus US14, US22; Ita US16) | F2. Match material flows with the known costs | |
| | | P2. Check the findings, verify the sustainability assessment findings.If not review the design (Aus US18, US26; Ita US19) | F3. Provide the life cycle calculations | |
| I3.M2.SM4 EKO | Circularity Assessment | | F1. Identify the metrics to be used for assessment | |
| | | P2. Check the findings, verify the sustainability assessment findings.If not review the design (Aus US18, US26; Ita US19) | F2. Report on these metrics | |
| | | P1. Utilise the LCIA and LCCA, conduct circularity assessment (Aus US14, US22; Ita US15, US16) | | |
| I3.M2.SM5 EUT | Water Treatment Assessment | | F1. Access the project data | |
| | | | F2. Extraction of building information form BIM model | |
| | | | F3. Access to meteorological data | |
| | | | F4. Access to user information | |
| | | | F5. Model structure | |

I4.M1: Blockchain Services for the Construction Processes Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I4.M1.SM1 IDP | Time Stamping/Versioning for Digital Twin Certification | | F1. Compilation of the below set of data for digital twin configuration<br>F2. Hash of Digital Twin file is compiled in an XML, Json structure<br>F3. Digital sign and store for future compliance and liability validation | Blockchain networks hash the content of blocks and store them in the header of block along with hash of the previous block automatically unless you are planning to create your own blockchain network from scratch there is no need to hash content of block again. |
| | | P1. Update the versioning for Digital Twin certification (Aus US 26, US29, US31, US32, US33, US35; Ita US19, US20, US21, US24, US25, US27, US33, US35, US36 | | It is extremely important to identify what information should be stored on blockchain at an early stage. Because of high transaction costs and block size limitations it may not be feasible to store things like files in the blockchain network. (or we can hash the |

| | | | | |
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| | | | | content of the document and store it) |
| I4.M1.SM2 EUT, VRM | Subcontracting Management | | F1. Subcontracting party is defined in the platform and project | |
| | | | F2. Information on their scope, responsibilities stored in the system | |
| | | | F3. Scope carried out by the party defined in the system and referenced to Digital Twin/ BIM sub components | |
| | | | F4. If a performance related obligation exists, that information and related obligations and liabilities are specified (I2.M1.SM3) | |
| | | | F5. Periodic need for validation and bookkeeping specified | |
| | | | F6. For the scope related obligations, Action (I1.M1.SM1) carried out with reference to the subcontracting party | |
| | | | F7. In the case of performance obligations, Action (I4.M1.SM2) carried out with reference to the subcontracting party | |
| | | P1. Subcontracting management during tendering bid review and acceptance (Ita US24, US25, | | |
| | | P2. Manage the general contractor, use this function during the roles and process matching (Ita US26. US27, US28, US29, US30, US31, US32) | | |

I4.M2: Construction Operation Management Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I4.M2.SM1 CREE, ASC | Site Role/Task Management | | F1. Sharing information in the right data format and quality | |
| | | | F2. Order based on BIM objects and BIM components | |
| | | | F3. During construction, continuous update of the BIM (Revit/ArchiCAD) model when something changes, create the *'As built' model*. | |

| | | | | |
|---|---|---|---|---|
| | | | F4. The As Built Model should include all data from Architecture, MEP, Structure and should include all required data for the desired purpose. | |
| | | | F5. Define roles and responsibilities within the project | |
| | | | F6. Create tasks related to BIM object | |
| | | P2. Assign roles and tasks (Aus US27, US29, US31; Ita US27, US28, US29, US30, US31, US32) | F7. Assign tasks to the concerned team/worker/role | |
| | | P3. assign tasks to building automation team and subcontractors for installation of building automation (Aus US33; Ita US34 ) | | |
| | | | F8. Locate the task in the building | |
| | | | F9. Report the task status (Open, Done, Extended Deadline, Failed) | |
| | | P3. Check the delivered prefab. Parts for the following acceptance (Aus US30) | F10. Provide a communication channel concerning a task between the concerned users/roles | |
| | | P1. Identify the required subcontractors and suppliers for the survey and identify the survey activities and outputs (for the survey contracting) (Aus US4) | | |
| I4.M2.SM2 CREE, ASC | Site Surveys and Inspection | | F1. Sharing information in the right data format and quality | |
| | | | F2. Quality inspection of prefabrication | |
| | | | F3. Transportation inspection | |
| | | | F4. Delivery and storage on-site | |
| | | | F5. Assembly process | |
| | | | F6. Final assembly quality control | |
| | | P1. Start the site survey and fill the audit/survey report (Aus US5; Ita US3, ) | | |
| | | P2. Organize site surveys and inspection to monitor the progress (Aus US29, US31; Ita US28, US29, US30, US31, US32, US33) | | Again, more detail is needed for organize, is it merging? Grouping them? Ordering them?<br>Ignoring them in the current operation? |
| I4.M2.SM3 CREE, ASC | | | F1. Sharing information in the right data format and quality | |

| | | | | |
|---|---|---|---|---|
| | Clash Detection Solving and Documenting | P1. Use it for clash detection documentation and solving (Aus US29, US31) | F2. Identifying clashes, locating them on-site and in the model | |
| | | | F3. Give the task to the responsible person to solve it and document it | |
| I4.M2.SM4 CREE, ASC | Progress Monitoring | | F1. Sharing information in the right data format and quality | Change? Is it change in status? Change in the content? What kind of reporting is needed? Mail? SMS? |
| | | P1. Constantly monitor the progress, reporting the change (Aus US29) Constantly monitor the progress, reporting every change (US30, US31, US32, US33, US34) (Ita US28, US29, US30, US31, US32, US33, US34, US35) | F2. Continuous monitoring and reporting from the whole construction process. | |
| | | | F3. Handle and solve changes and delays, reporting them | |

I4.M3: Construction Document Management

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I4.M3.SM1 EKO | Design-As Built Data Compliance | P1. Based on monitoring activities update the design 'As built' data using the design and progress documents (Aus US29, US31, US32, US33; Ita US33, US34) | F1. | This user story is delivered by the Digital Twin Configuration management user story items |
| | | P2. Check the as built model compliance (Ita US36) | | |
| I4.M3.SM2 NEX, VRM | Improving the Process and Change Management | P1. Constant feedbacks (Aus US29, US30, US31, US32; Ita Us28, US29, IS30, US31, US32, US33, US34 ) | F1. Identify change request<br>F2. Identify approval needs<br>F3. Approve change<br>F4. Create required set of documents for change specifications<br>F5. Relate change request to requirements/objects in the database | Feedbacks in what form? |

I4.M4: Regulatory Compliance Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| I4.M4 VRM | Regulatory and Compliance Checks | P1.set value by regulations/ Check whether results are within the acceptable range determined by regulatories (Aus US13, US21; Ita US8, ) | | Is it automatic or manual? |
| | | P2. Check the findings, verify the design.If not review the design (Ita US11, US19) | | |
| | | P3. Constantly check with regulatories, if not report as a feedback (Aus US14, US18, US20, US22, US26; Ita US13, US14,US35 ) | | |
| | | P4. Check the regulatory compliance, legal integrity, qualification, skill and required certification of the project manager and construction manager team. (Ita US20, US21, US22, ) | | |
| | | P5. Check construction companies participating in the tender in the regulatory compliance, legal integrity and required certification (iso 9001, iso 14001 etc.) (Ita US23) | | |
| | | P6. Check construction companies contracting the regulatory compliance and legal integrity for contract agreement (Ita US25) | | |

I4.M5: Comissioning

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I4.M5.SM1 IDP, EKO | Comparison of Energy Simulation and Real Values | P1. Compare the simulation results with the real values after the installation of the automation systems, report the results (Aus US33; Ita US34) | F1. Building Energy Consumption parameters are defined:<br>Description on scope of coverage of consumption data (whole building or zones of building) [In case of multiple power meters, multiple entries are needed]<br>Occupancy conditions [User numbers, Operational practices if any (natural ventilation etc.)] | I think it would be helpful to identify how we are going to report the results. Is it a report? Changing the color of row that contains the |

| | | | | |
|---|---|---|---|---|
| | | | F2. Energy Consumption data is compiled,<br>Manual Process: [The bills are entered into the platform]<br>Automated process: [Data sources are related to the above defined building zone/parameters are defined, Automated flow of data streamlined] | simulation to green/red? |

I4:M6: Handover Management

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I4.M6.SM1 NEX, VRM | Handover Data Management | | F1. Review building specific documents | |
| | | | F2. Assess for confidentiality | |
| | | | F3. Collate guarantees/contract documents | |
| | | | F4. Commence defects liability period | |
| | | | F5. Record handover acceptance | |
| | | | F6. Manage defects/handover refusal | |
| | | P3. Hand over operational & technical info to client (Aus US36; Ita US37) | F7. Collate handover information in an occupant-only environment | |
| | | | F8. Provide managed & limited access to occupant | |
| | | | F9. Link handover documents/information to the Digital Twin | |
| | | | F10. Communicate handover to project partners | |
| | | | F11. Collate O&M documents | |
| | | | F12. Collate H&S file | |
| | | | F13. Satisfy GDPR requirements | |
| | | P1. Complete the handover using the building automation data and the Handover strategy (Aus US34; Ita US35) | | |
| | | P2. Review the progress monitoring reports, update 'As built' information based on design as built data and submit performance reports (Aus US35; Ita US36) | | |

I5.M1: Facility Management Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I5.M1.SM1<br>IDP, EUT, VRM | Organizing Maintenance Schedules | P1. Use the acquired data from the facility and technical documents ( BIM and life cycle assessment reports) determine maintenance dates (Aus US37; Ita US38)) | F1. Enable user defined rules for maintenance schedules<br>F3. Trigger warning when maintenance operation is approaching according to programmed rules | |
| | | P2. Check the compiled reports to identify root cause and maintenenace details (Aus. 38; Ita US39) | F4. Create decision support trees based on use-case reasoning | |
| I5.M1.SM2<br>TNO | Decision Making for Refurbishment | P1. Using the maintenance and status reports, determine refurbishment requirements (Aus US37; Ita US38) | F1. Create report | |
| | | P2. Check the compiled reports to identify root cause and maintenenace details (Aus US38; Ita US39) | | |
| | | | F2. Export data | |
| I5.M1.SM3<br>VRM, ASC | Building Issue Management | P2. Check the compiled reports to identify root cause and maintenenace details (Aus. US38; Ita US39) | F1. Create/report issue | |
| | | | F2. Overview of the site issues status for site managers and direct site responsible | |
| | | P1. Use this tool to identify and reseolve the unexpected issues (Aus US37: Ita US38) | | |
| I5.M1.SM4<br>COMSA,EUT | Big Data Analytics for Predictive Maintenance | P1. Based on the previous maintenance pattern and product details, anticipate the possible maintenance dates (Aus US37; Ita US38) | F1. Feature selection: select variables affecting equipment operation<br>F2. Estimate need for maintenance based on real operation conditions<br>F3. Create decision support trees based on use-case reasoning (explanatory scheme)<br>F4. Self-learning capabilities: new cases enhance the automatic decision-making process | Extension from I5.M1.SM1 (preventive and predictive maintenance). As the amount of data grows, expert knowledge (rule-based) is replaced by AI. |
| | | P2. Check the compiled reports to identify root cause and maintenenace details (Aus US38; Ita US39 ) | | |

I5.M2: Energy Management, Performance Management

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I5.M2.SM1<br>ED5 | | | F1. Access project data | |
| | | | F2. Privacy agreements for data sharing | |

| | | | | |
|---|---|---|---|---|
| | Data Acquisition and Status Reporting | | F3. General agreements specifying the correct use without any manomission of them | |
| | | | F4. Report of the initial calibration of the sensors and approval of a calibration plan of the sensors | |
| | | | F5. Internal general verification of the installed sensor | |
| | | | F6. Transmission of measured data to the platform | |
| | | | F7. Definition of roles for the users | |
| | | | F8. Duration of stored data | |
| | | P1. Platform automation collects the data and transfer it for further analyses (Aus US37; Ita US38) | | |
| I5.M2.SM2 EKO | Dynamic Env. Assessment and Communications | P1. Platform automatically decides (Aus US37; Ita US38) | F1. Energy consumption data, compiled in I4.M5.SM1 is processed into: [Consumption of zone(s) / time period, Consumption of whole building / time period] | |
| | | | F2. Set points for buildings identified as alert points of medium and high consumption (KPIs from WP2 used such as kWh/m2) | |
| | | | F3. Related building project actors identified in relation to the alerts | |
| | | | F4. Automated alarm triggers identified if any needed to a [A project, An actor/stakeholder, Project/sub zone, KPI, Quantity, Type of alert] | |
| I5.M2.SM3 EUT, TNO, EKO, EAI | Energy Use Optimization | P1. Using the energy simulation results conduct energy optimisation (Aus US37; Ita US38) | | This part is exactly the same as **I5.M2.SM4**. There is not foreseen any specific module focused on the energy optimization. |
| I5.M2.SM4 EUT | Energy Generation Evaluation and Decision Support | | F1. Access the project data | |
| | | | F2. Extraction of building information from BIM model | |
| | | | F3. Access to meteorological data | |
| | | | F4. Access to user information | |
| | | | F5. Model structure | |
| | | P1. Based on the acquired data, platform automatically conducts simulation and results are utilised in decision support and other activities (Aus US37; Ita US38) | | |

| | | | | |
|---|---|---|---|---|
| I5.M2.SM5<br>VTT | Human Thermal Model Building Automation Control | P1. Based on the acquired data, platform automatically conducts simulation and results are utilised in decision support and other activities (Aus US37; Ita US38) | | |
| I5.M2.SM6<br>R2M, VRM | Energy Management ICT tool – ISO 50001 Decision | | F1. Access current and historic energy data<br>F2. Review savings<br>F3. Review advice<br>F4. Communicate data<br>F5. Communicate recommendations<br>F6. Observe results of changes made | |
| | | P1. Simultaneously with the energy simulation and optimisation, energy management tool assess the results and provides the best solutions automatically (Aus US37; Ita US38) | | |
| I5.M2.SM7<br>DE5 | Reporting | | F1. Definition of template for reporting<br>F2. Export results with a simplified content: PDF<br>F3. Export results with a fully set of content: XLS/CSV<br>F4. Define time-lapse for automatic reporting<br>F5. Agreement for the use of data and definition of: role and scope from the user data | |
| | | P1. Compile reports on energy management are created and delivered to the (Aus US37; Ita US38) | | |

I5:M3: Financial Monitoring and Account Keeping Module

| Coding | Name | Feature from pilots | Features from software tool providers | Notes |
|---|---|---|---|---|
| I5.M3.SM1<br>EUT, EKO | Smart Contract Based Open Ledger Book-Keeping | | F1. The specified financial valuation, timing and responsible part definition retrieved from the related project Management definition dataset<br>F2. Related approval procedure specified to a user<br>F3. Base on the Smart Contract liabilities, the financial debt equivalent of the scope of work is | |

| | | | | |
|---|---|---|---|---|
| | | | quantified, and the debtor and the recipient party addressed | |
| | | | F4. The related verified version from I4.M1.SM1 retrieved | |
| | | | F5. The related financial transaction is made with evidence reference | |
| | | | F6. The open ledger of the project stores the transaction in the distributed framework | |

# Appendix C – SPHERE Partner Software Templates

| Acronym | Tool name | Tool provider | Location | Status |
|---|---|---|---|---|
| iESD_E | Intelligent Energy Designer | Eurecat (Appendix C.1) | Appendix C1.1 | Complete |
| iESD_W | Intelligent Water Designer | | Appendix C1.2 | Complete |
| iPREDICT | Predictive Maintenance Tool | | Appendix C1.3 | Complete |
| IMAN | IMAN - Computerized Maintenance management System | COMSA (Appendix C.2) | Appendix C2.1 | Complete |
| HTM | Human Thermal Model | VTT (Appendix C.3) | Appendix C.3.1 | Complete |
| EPESUS | EPESUS | EKO (Appendix C.4) | Appendix C4.1 | Complete |
| CMT | Concrete Management Tool | BASF (Appendix C.5) | Appendix C5.1 | Complete |
| OPT | Operational Planning Tool | | Appendix C5.2 | Complete |
| FRCT | Fiber Reinforced Concrete Tool | | Appendix C5.3 | Complete |
| LCCCA | Life Cycle Cost Concrete Assessment | | Appendix C5.4 | Complete |
| En-MS | Energy Management System | R2M (Appendix C.6) | Appendix C6.1 | Complete |
| ECOSIMPRO | ECOSIMPRO | EAI (Appendix C.7) | Appendix C7.1 | Complete |
| Refurbify | Refurbify | VRM (Appendix C.8) | Appendix C8.1 | Complete |
| Clarity | Clarity | | Appendix C8.2 | Complete |
| ModSCO | ModSCO | NUIG (Appendix C.9) | Appendix C9.1 | Complete |
| RobMOS | RobMOS | TNO (Appendix C.10) | Appendix C10.1 | Complete |
| FLINK2GO | FLINK2GO | ASC (Appendix C.11) | Appendix C11.1 | Complete |
| NEXT | NEANEX PORTAL | NEANEX (Appendix C.12) | Appendix C12.1 | Complete |

## C.1 Eurecat iESD_E, iESD_W, iPREDICT

# C1.1 Intelligent Energy Designer (iESD_E)

| iESD_E | |
|---|---|
| Software Overview | |
| **What is the purpose of the software tool within the context of the SPHERE platform?** | iESD (intelligent Energy System Designer) is a tool focused on the determination of the optimal retrofitting actions to be made on a given building, considering both technologies for the building´s cover and roof, as well as technologies for the energy production, conversion and supply.<br><br>It is based on the combination of mathematical models that characterize the annual energy demand vectors of a given building (based on its characteristics) and a multiobjective optimization engine that evaluates the different available retrofitting actions for both the envelope, cover and energy equipment of the building, with objective to determine the optimal ones in terms of multi-criteria approach (e.g. energy efficiency, investment and maintenance costs, $CO_2$ emissions).<br><br>The tool developed is at TLR 5 since has been validated in an experimental environment, but has to be tested in an operative commercial environment. |
| **How is the software tool to be used and by whom?** | It is a visible service.<br>The life cycle stage at which it can be used is either at design or retrofitting.<br><br>Due to its structure and modular operation, the tool can be used by prescribing technicians, energy services companies, maintenance companies, engineering services or architectonical bureaus as well as consultancies and the end users, focusing only on the passive part (envelop and cover), active part (energetic equipment), or in the entire chain, always to assessing the impact of targeted actions previously selected. |
| **What does the end user get from using the software tool in terms of results?** | Calculates and evaluates the energy requirements of the building (heating, cooling, DHW and lighting). Then, it studies potential passive and active solutions to be installed in the building and **analyse their impact in terms of energy, costs and sustainability**. Determine the most efficient equipment to be installed in the building, based on its demand profiles, building's conditions and the optimization criteria. |

| | |
|---|---|
| | As well as, it evaluates which renewable energy technology is the most suitable to install in the building according to its climatic condition, use and architectonic characteristics (e.g. available surface for panels). |
| **What are the main benefits from the results provided by the software tool?** | Determine the optimal passive and active technologies to be installed in the building according economical, technical, efficiency and sustainability impacts among others. |
| **Which SPHERE sub-modules does the software relate to?** | I3.M1.SM5, I5.M2.SM3 and I5.M2.SM4. |
| **Screenshots (four)** | |
| There are some screenshots of the provisional mockups, however the user interface is pending to be defined and validated. | |
| **Description of BIM USE** | |
| **Does the software use data from a BIM file?** | Yes, it does. The data needed from the BIM file is: the architectonical parameters (i.e. building shape, number of floors), the climatic conditions (i.e. building situation) and the building's typology (i.e. usage profile, occupation, schedule). |
| **What type of (BIM) files does the software need / will it be built for?** | IFC. |
| **Does the software generate data that can be added to a BIM file?** | No. |
| **Description of other DATA** | |
| **What other datasets are needed from other tools or entered by the user?** | The historical energy demand (heating, cooling, DHW, lighting) vectors of the given building. |
| **Does the software generate/provide for any specific files and formats?** | No. |
| **Service Architecture** | |
| **How would the software interface with the SPHERE platform?** | At the moment there aren't linkages considered between the iESD_E tool and any other tool, only with the Sphere platform. |

# C1.2 Intelligent Water Designer (iESD_W)

| iESD_W | Not yet available |
|---|---|
| Software Overview | |
| What is the purpose of the software tool within the context of the SPHERE platform? | The tool is focused on three main aspects related to the building and its location: to obtain the annual water demand and its quality requirements, to determine the available wastewater and rainwater per year and to recommend the most suitable water treatment technology. In order to do so, the tool will connect to the corresponding databases to obtain the required input data.<br>The corresponding TRL for the tool is 4 since it has been validated at the laboratory scale. |
| How is the software tool to be used and by whom? | This tool is a visible service. The tool can be used by engineering firms, service and maintenance companies, local administration, environmental associations and building residents. The life cycle stage at which it can be used is either at design or retrofitting. This tool will automatically connect to the different databases to obtain the inputs for the models and will provide the most suitable options for the user. |
| What does the end user get from using the software tool in terms of results? | The output for the user will contain water availability (both greywater and rainwater), water requirements of the building (related to irrigation and toilet discharge) and a recommendation for the most suitable water treatment technology to be installed taking into account different parameters (climatic condition, use, architectonic characteristics and its water requirements). It may also determine the optimal sizing of the recommended technology. |
| What are the main benefits from the results provided by the software tool? | The tool will provide a recommendation of the most suitable water treatment technology to be used, both from an economical and environmental point of view, as well as the water availability and requirements for a given building. |
| Which SPHERE sub-modules does the software relate to? | I3.M2.SM5 |
| Screenshots (four) | |
| Pending to be defined. | |
| Description of BIM USE | |
| Does the software use data from a BIM file? | Yes, it does. It needs to obtain information related to the building and its location, as well as data from climate databases to include annual water availability. |
| What type of (BIM) files does the software need / will it be built for? | Probably IFC or gbXML but still to be determined. |
| Does the software generate data that can be added to a BIM file? | No. |
| Description of other DATA | |

| | |
|---|---|
| What other datasets are needed from other tools or entered by the user? | Meteorological data related to average annual rainwater disposal, specific site legislation regarding quality requirements and/or allowed water usage. |
| Does the software generate/provide for any specific files and formats? | No. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | To be defined. |

# C1.3 Predictive Maintenance Tool (iPredict)

| iPredict | [ add Logo if any] |
|---|---|
| Software Overview | |
| What is the purpose of the software tool within the context of the SPHERE platform? | A maintenance module based on AI and machine learning which enables to minimize downtimes due to unexpected breakdowns and reduce energy waste due to malfunctioning or misuse of equipment. Initially designed for heating and air conditioning and in water heating systems; it can be extended to other equipment or building elements and target structural instability, leakage and other safety risks that may derive in unforeseen construction work and use of resources, energy among them.<br><br>iPredict is a tool focused on the generation of early warnings to avoid major damage and downtimes. The machine learning engine relies of the existence of big data to extract patterns and variable dependencies to detect anomalies and trigger alerts. However, for new installations or systems where not such amount of historical data exists, or for more basic operation, the tool accepts the configuration of rules (expert knowledge) to trigger alarms whenever a configured threshold is reached. Compared to more basic tools, the rules to trigger a maintenance requests can be calculated based on real operations conditions (not calendar days but operation hours). As more data is provided to the system, the thresholds are estimated automatically based on statistics.<br><br>The tool developed is at TLR 5 for domestic boiler predictive maintenance operation. . |
| How is the software tool to be used and by whom? | iPredict is a module. It relies on data gathered and stored by other components (request to a repository).<br><br>The results of the module will be fed into a repository and send to IMAN, where the interaction will be done through a GUI.<br>An additional GUI for system configuration and rule definition needs to be developed.<br>The target users are mainly facility managers and technicians.<br><br>Configuration of the system and rule settings will be performed by domain experts (experienced technicians, engineers). |
| What does the end user get from using the software tool in terms of results? | It enhances maintenance operation. The advance preventive maintenance offered enables to better adjust maintenance actions based on real operation conditions rather than periodically pre-defined actions. The predictive features enable to avoid downtimes, minimize complaints and better plan staff schedules. |

| | |
|---|---|
| What are the main benefits from the results provided by the software tool? | It eventually reduces costs and increases customers satisfaction. |
| Which SPHERE sub-modules does the software relate to? | I5.M1.SM1 and I5.M1.SM4. |
| Screenshots (four) | |
| Pending to be defined. | |
| Description of BIM USE | |
| Does the software use data from a BIM file? | Yes, it might. The data needed from the BIM file is: the climatic conditions (i.e. building situation), the building's typology (i.e. usage profile, occupation, schedule) and parameters of equipment (HVAC). |
| What type of (BIM) files does the software need / will it be built for? | IFC or gbXML. |
| Does the software generate data that can be added to a BIM file? | No. |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | The historical energy demand (heating, cooling, DHW, lighting), temperature, equipment set-points. |
| Does the software generate/provide for any specific files and formats? | No. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | To be defined. There are different options, but it is not defined yet. |

## C.2 COMSA - IMAN

| CMMS |  |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | Brief description<br>IMAN v5 is a CMMS software developed by COMSA Service to support its main activity as Facility Management and Maintenance Company. The tool has been continuously improved, adding new features, such as integration with BIM.<br>Technological maturity level (TRL)<br>The software meets a maximum maturity level, corresponding to a *TRL9* since it is a real system tested in an operational environment. The software and its continuous evolutions are common tools in many of the contracts managed by COMSA Service. |
| How is the software tool to be used and by whom? | Is it an application (hidden) or a visible service?<br>The software represents a visible service since it is the tool used to manage and plan all maintenance and facility management operations. In a BIM environment, it can work in a hidden and accessible way directly from the model, being able to generate simple interactions with the CMMS software<br>End users<br>There are different types of end users. From the operator who performs the maintenance operations to be performed, the maintenance technician who is responsible for programming and managing all maintenance tasks to the end user of the facility that can generate notices for maintenance needs.<br>Life cycle stage in which it is used<br>The software is mainly used in the operation and maintenance phase of buildings. Although it can be used to manage work orders in all phases of the asset life cycle<br>Usage of product<br>It is used to plan and manage all maintenance and facility management operations, as well as a ticketing tool to manage notices sent by the end user. |
| What does the end user get from using the software tool in terms of results? | Format of result<br>The result of using this tool is the monitoring, management and planning of all maintenance operations, whether corrective, preventive or predictive. Additionally, it allows to report the results of this process. In turn, it allows to have the history of maintenance operations and breakdowns of the assets.<br>Description of results |

| | |
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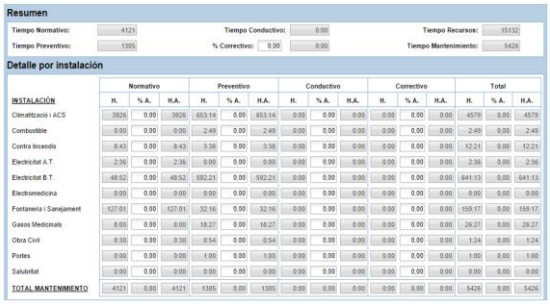
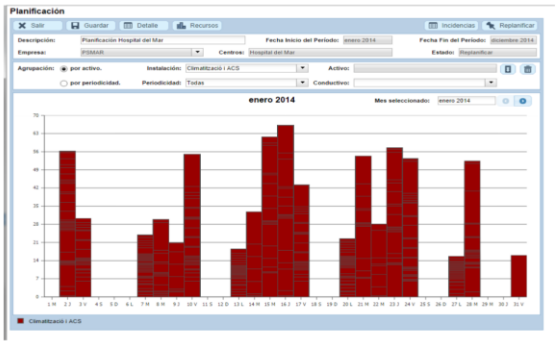
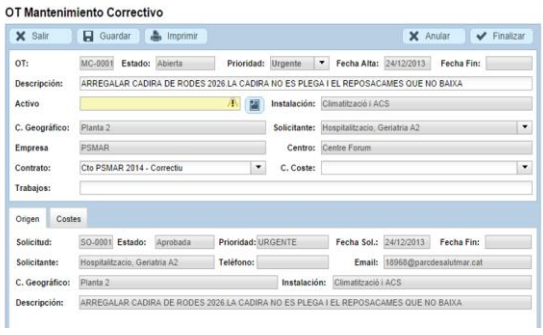
| | The results of the use of the software are diverse depending on the profile. For maintenance personnel it allows to know the planning of tasks and the notices of the activities to be carried out. On the other hand, from the client's point of view, he can check the progress of the work and obtain a periodic report. |
| What are the main benefits from the results provided by the software tool? | Performance benefits<br>It is a software developed with total customer orientation, so COMSA Service adapts the performance of the tool to the real needs of the client (servers, users, roles, etc.). It is possible, in cases where the client requests it, to adapt the installation and the performance of the tool to its own on-premise servers.<br>Cost/financial<br>There is no license cost for the software beyond the cost of cloud servers. |
| Which SPHERE sub-modules does the software relate to? | I5.M1.SM1<br>I5.M1.SM3<br>I5.M1.SM4 (the hard link) |
| **Screenshots (four)** | |
|  |  |
|  |  |
| **Description of BIM USE** | |
| Does the software use data from a BIM file? | Yes<br>Brief description of data needed<br>The software needs the input of the inventory data (detailed) and the information associated with it (datasheets, installation manual, user manual, certificates, commissioning sheets, etc.). Additionally, the linking of assets to physical spaces |

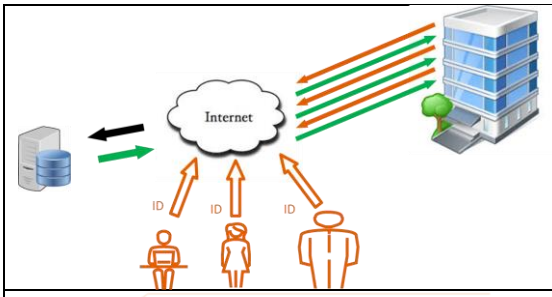
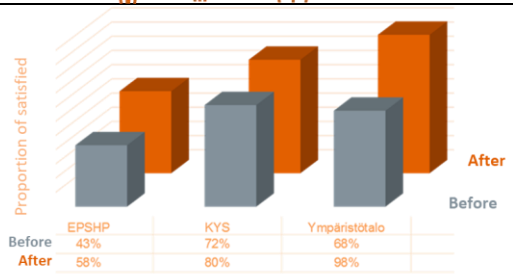
| | |
|---|---|
| | allows to optimize the routes of maintenance activities. |
| What type of (BIM) files does the software need / will it be built for? | IFC? gbXML?<br>Through a middleware working as a viewer of the BIM model, IMAN software can communicate, via API, with any BIM format, native (.rvt) or open (.ifc).<br>Other – COBie<br>The entry of data from previous phases of the facility lifecycle is expected to be done through a COBie format. This is usually one of the main pain points for the use of this type of software. The software is prepared for direct data loading through a COBie datasheet. The system automatically interprets the files in COBie format and loads the inventory items and their characteristics, significantly reducing the resources required for this phase. |
| Does the software generate data that can be added to a BIM file? | Yes<br>Description of data<br>Yes, but in no case is the software expected to generate data that modifies the geometric component of the native BIM file. The tool allows the edition of the data and metadata of families, systems or spaces. Additionally, if any parameter of the equipment is modified, this information reverts bi-directionally between both systems. |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | Description of other data requirements<br>When using custom assets (those who are not present in the application database), the user is required to upload an Excel file containing the asset data to be imported. Those new assets will be merged with the current ones already on the application.<br>Additionally, the data referring to the performance of the assets from the IoT platform and interpreted by the iPredict platform generate actions to create work orders in the asset in question. |
| Does the software generate/provide for any specific files and formats? | Description of files generated?<br>Specific reports are generated in PDF format. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | API<br>The application has a REST API serving JSON files through HTTPS protocol.<br>Manual use with data files<br>Certain files (such as .csv, .xls, .txt, etc) could be parsed into the app with no hassle.<br>Description of the process |

| | |
|---|---|
| | The API service callings between the platform and the application is preferred when available, adapting authentication procedures as needed. |

## C.3 VTT - HTM

# C3.1 Human Thermal Model (HTM)

| Human Thermal Model | |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | Human Thermal Model software enables demand-based and individual control methodology of thermal indoor environment. It provides autonomous definition of individual temperature set-point values for occupants, and these individual thermal preferences can further been fine-tuned by feedback related to thermal experiences. In addition, HTM software enables to monitor how different types of fictional people experience measured indoor thermal environment. Technological maturity level (TRL): TRL 7/9 |
| How is the software tool to be used and by whom? | HTM will be used to control individual thermal indoor environment and monitor how different types of fictional people experience measured indoor thermal environment. From technical point of view, HTM control solution need to be properly integrated into building automation system and its operation can be monitored by facility managers. From utilization point of view, this technology is used by occupants - simply by giving feedback of how they have experienced the thermal conditions. |
| What does the end user get from using the software tool in terms of results? | End users will have pleasant thermal conditions, controlled according to their individual expectations. In addition, building facility managers will get information on which spaces and at what times there have been challenges in studied person type thermal comfort. |
| What are the main benefits from the results provided by the software tool? | HTM control technology will improve occupants' thermal satisfaction and energy efficiency of buildings (by avoiding unnecessary heating and cooling). In addition, by HTM monitoring, building facility managers will improve the quality of service by finding thermal comfort problems more easily. |
| Which SPHERE sub-modules does the software relate to? | I3.M1.SM7 Human Thermal Model<br>I5.M2.SM5 Human Thermal Model Building Automation Control |
| **Screenshots (four)** | |

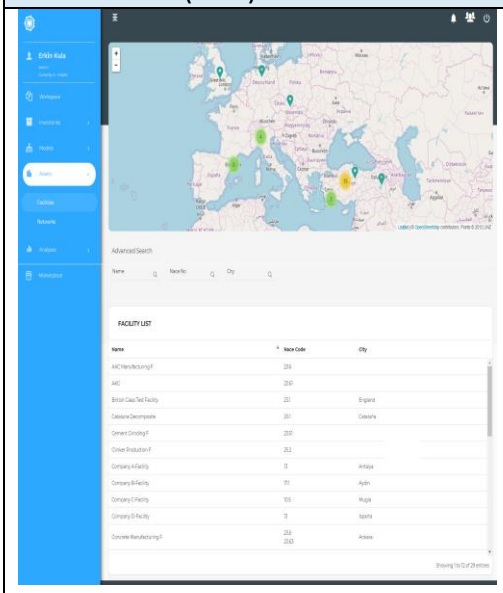
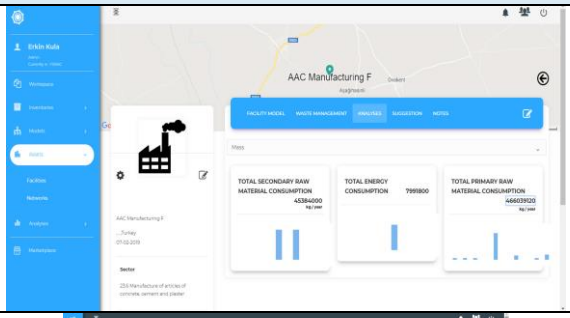
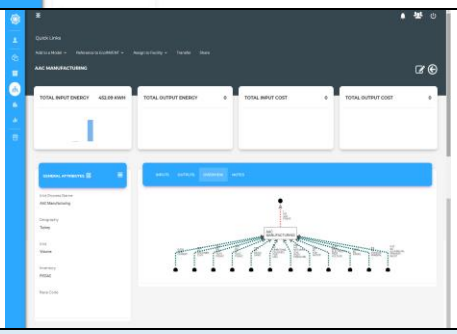
<table>
<tr>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td> 
</td>
<td>  </td>
</tr>
<tr><td colspan="2">Description of BIM USE</td></tr>
<tr><td>Does the software use data from a BIM file?</td><td>Optional feature. Not in basic setup but the BIM data can be used if also studied space related surface temperatures are measured.</td></tr>
<tr><td>What type of (BIM) files does the software need / will it be built for?</td><td>Optional feature. Architectural BIM models (including ifcSpace and related geometry) can be used via BIM Model server API or manually by BIM files.</td></tr>
<tr><td>Does the software generate data that can be added to a BIM file?</td><td>No, only manufacturer-specific BIM content extension can be implemented as optional.</td></tr>
<tr><td colspan="2">Description of other DATA</td></tr>
<tr><td>What other datasets are needed from other tools or entered by the user?</td><td>Datasets needed for HTM service internal configuration:<ul><li>Occupant data (real or fictional person id, gender, age, BMI, fitness, clothing, activity)</li><li>Space data (space id, space indoor air temperature measurement point id, space indoor air humidity measurement point id, optional space surface temperature measure points’ ids, optional space surfaces’ geometries)</li></ul>Datasets needed from other tools when calling HTM REST API (space id, real or fictional person id, optional start time, optional end time) or SPHERE measurements based HTM REST API (temperature sensor value, relative humidity sensor value, real or fictional person id).</td></tr>
</table>

| | |
|---|---|
| Does the software generate/provide for any specific files and formats? | The result data (time stamped thermal sensation and optionally also room controller's or radiator thermostat's setpoint) can be read online via REST APIs. Results as Excel files can be download manually if needed. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | Cloud based with REST API. |

## C.4 EKO - CEAT

# C4.1 Circular Environmental Assessment Toolbox (CEAT)

| | |
|---|---|
| CEAT (formerly EPESUS) |  |
| Software Overview | |
| What is the purpose of the software tool within the context of the SPHERE platform? | The CEAT toolbox purpose is for life cycle analyses based on BIM data files, so as to rapidly allow for the generation of environmental and circularity footprints of buildings.<br>It includes: 1) Life Cycle Assessment (LCA) to assess the environmental impacts of buildings and to generate different scenarios depending on building materials used. 2) Life Cycle Costing (LCC), to create combined environmental impact and cost scenarios. 3) Circular economy assessment scenarios on the re-use and recycling potential of buildings.<br>The purpose is to calculate key performance indicators, to increase resource efficiency in production processes, and to adapt to the continuously renewed environmental legislation.<br>The Technological maturity level (TRL) is at TRL 5 for the entire building life cycle (TRL 6 for the construction materials cycle). |
| How is the software tool to be used and by whom? | The tool serves currently to support design assessments for design/architects, and construction/renovation companies to provide for an as built overview of the environmental/cost/circularity footprint, and for LEED/BREEAM assessors as a calculation tool. |
| What does the end user get from using the software tool in terms of results? | After the updating of the tool the user will obtain an materials and environmental footprint of the desired renovation or new build building compliant with ISO 14040 LCA and EN 15978:2011 (environmental performance of buildings) with related KPIs, and a life cycle costing in line with ISO 15686-5:2017, and can also obtain insights in the circularity status of |

| | |
|---|---|
| | the building and renovation/construction processes in terms of recycling and re-use |
| What are the main benefits from the results provided by the software tool? | Utilisation in improving building design for higher environmental and circular standards , lower cost BREAM and WELL certification, improved insights in circularity for deconstruction of buildings. |
| Which SPHERE sub-modules does the software relate to? | I3.M1.SM2 Targets and Metrics<br>I3.M2.SM1 Material Flow Management<br>I3.M2.SM2 Life Cycle Impact Assessment<br>I3.M2.SM4 Circularity Assessment |
| Screenshots (four) | |
|  |  <br>  |
| Description of BIM USE | |
| Does the software use data from a BIM file? | Yes the version to be provided for the SPHERE project will utilise building elements and related information from BIM files. |
| What type of (BIM) files does the software need / will it be built for? | The developments will be built for IFC files |
| Does the software generate data that can be added to a BIM file? | Yes the materials footprints information will be calculated from volumes of elements, and can potentially be added to the IFC |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | The tool will use standardised typologies of buildings with life cycle inventory data on materials, so as to fill in any gaps from the IFC file if types of materials information is missing. It will be linked to existing life cycle inventory databases. The tool will also utilise a technology dataset for construction and deconstruction processes for calculating energy and carbon emissions, and to ascertain the recycling and re-use potential of building materials. |

| | |
|---|---|
| Does the software generate/provide for any specific files and formats? | Standard formats will be used based on XML/JSON formats, and a .csv format. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | Cloud based with an API |

## C.5 BASF – CMT, OPT, FRCT, LCCCA

# C5.1 Concrete Management Tool (CMT)

| Concrete Manager Tool (CMT) | Logo if available |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | Assessment of concrete mixture sustainability. The Technological maturity level (TRL) is 8. |
| How is the software tool to be used and by whom? | The users are AEC community & Concrete producers and it is used during renovation and construction works https://gabi-envision.basf.com/Envision/ |
| What does the end user get from using the software tool in terms of results? | Assess and reports most of the economic and environmental indicators detailed in EN 15804. Assess the environmental footprint of ready-mixed and precast concrete based on EN 15804. Allows quick calculations of environmental indicators and cost impacts for real concrete mix designs. Allows direct comparison of different scenarios and varying production installation and concrete disposal situations. Delivers a comprehensive report for concrete EPDs, and input for green building rating schemes (BREEAM, LEED, DGNB, HQE). Provides related production data (energy, water consumption), material cost, transport, data for installation and use, recycling and disposal for concrete management. |
| What are the main benefits from the results provided by the software tool? | Several different concrete mix-designs can be compared simultaneously, allowing the comprehensive analysis of “what if” scenarios and finding environmentally preferable and cost effective. |
| Which SPHERE sub-modules does the software relate to? | I3.M2.SM2 |
| **Screenshots (four)** | |

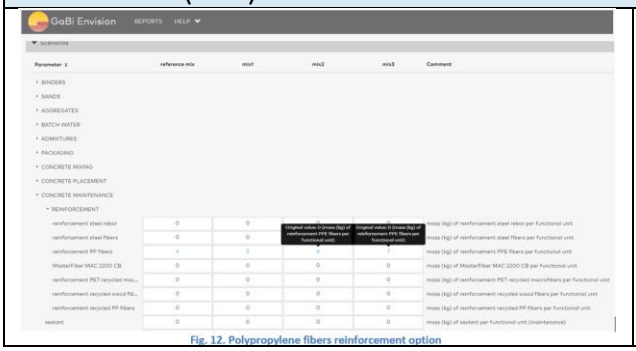
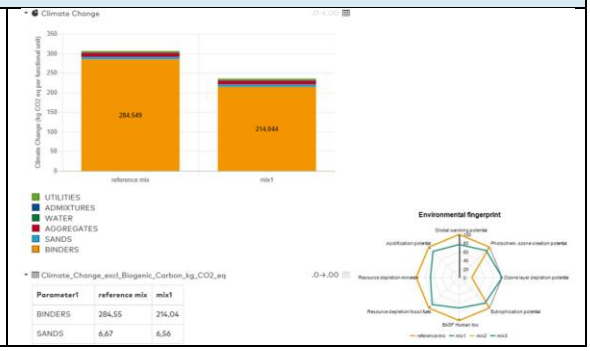



Fig. 12. Polypropylene fibers reinforcement option



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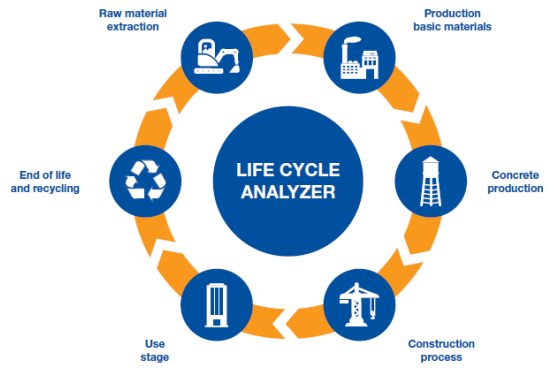
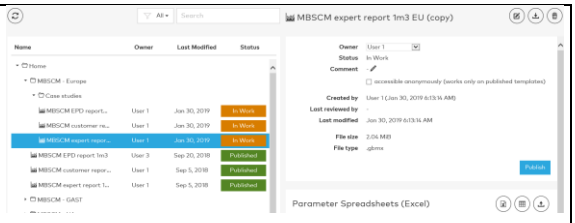
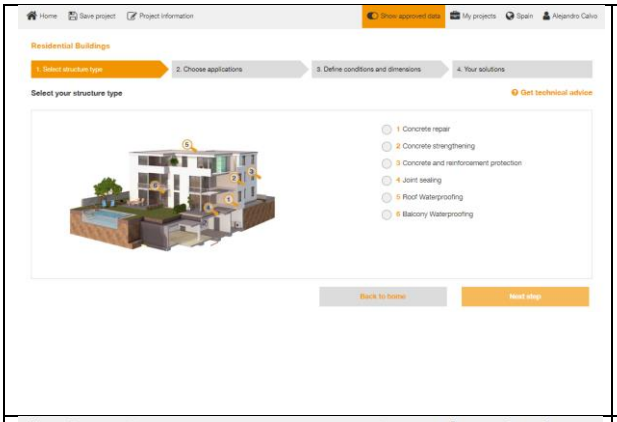
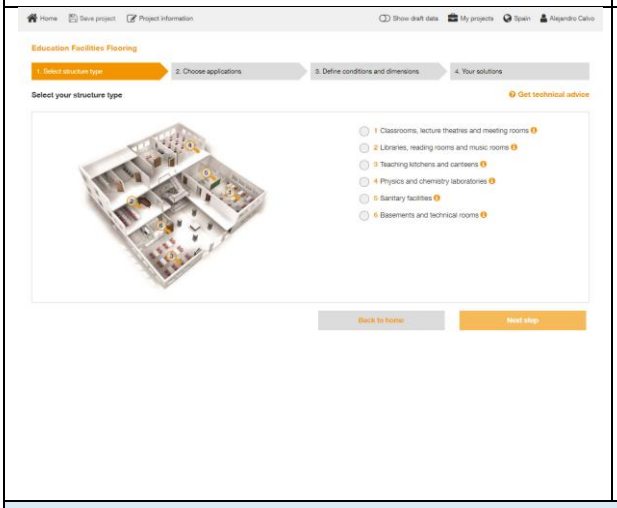
|---|---|
|  |  |
| Description of BIM USE | |
| Does the software use data from a BIM file? | Not currently |
| What type of (BIM) files does the software need / will it be built for? | None |
| Does the software generate data that can be added to a BIM file? | Probably; environmental indicators to be included in BIM elements. |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | Data input may also be uploaded from the Excel file *input_template_MBSCM.xlsx* |
| Does the software generate/provide for any specific files and formats? | Results may be viewed online as diagrams & tables or as a report.<br>Reports may be exported as PDF or RTF (rich text format, compatible with MS Word). |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | Online link:<br>https://gabi-envision.basf.com/Envision/ |

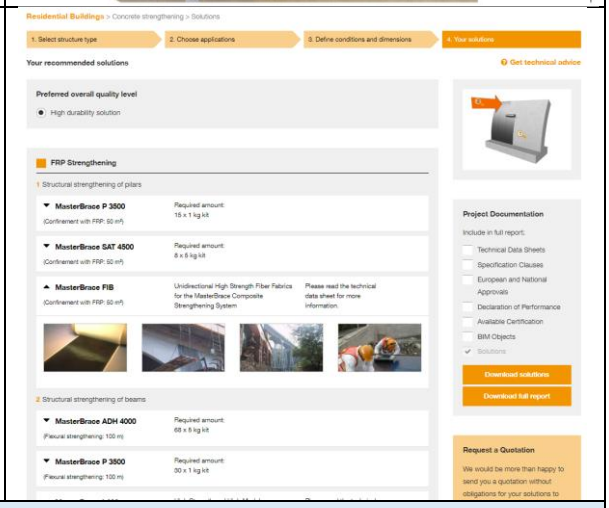
# C5.2 Online Planning Tool (OPT)

| Operational Planning Tool | Logo if available |
|---|---|
| Software Overview | |
| What is the purpose of the software tool within the context of the SPHERE platform? | Develop an On-line planning tool (OPT) to select the best repair/coating solution for a specific situation in the building, considering sustainability, durability and long- term performance of the structure. Will be linked externally and will be online. TRL to be updated |
| How is the software tool to be used and by whom? | The tool will be used by construction managers, architects and engineers, contractors and maintenance service companies, in the concept design and technical design phase, as well as during construction and assembly and in-use. |
| What does the end user get from using the software tool in terms of results? | Prevents information overload, provides specific BIM objects for repair/coating solutions. Provides changing project requirements and provides crucial information along each step of the project planning process, offering additional details about the selected products. |
| What are the main benefits from the results provided by the software tool? | As a **construction manager** it will help me to request product and application pricing information. As an **architect and engineer, as well as contractor and maintenance service company** it will help me to find the right solutions for my projects in a safe, fast and efficient way, and download the relevant BIM objects directly without the need to surf through several databases. As a **contractor** it will help me to compare different solutions for my projects. Request product and application pricing information, and adjust to changing project requirements and provides crucial information along each step of the project-planning process, and additional details about the products selected. |
| Which SPHERE sub-modules does the software relate to? | I1.M2.SM1; I1.M4.SM2; I1.M4.SM3; I5.M1.SM2 |
| Screenshots (four) | |

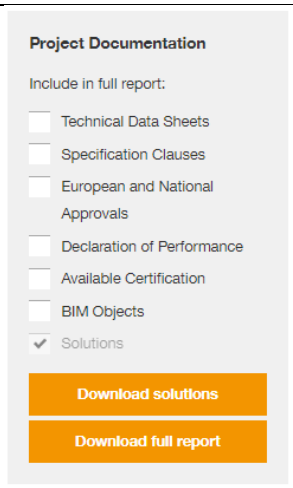






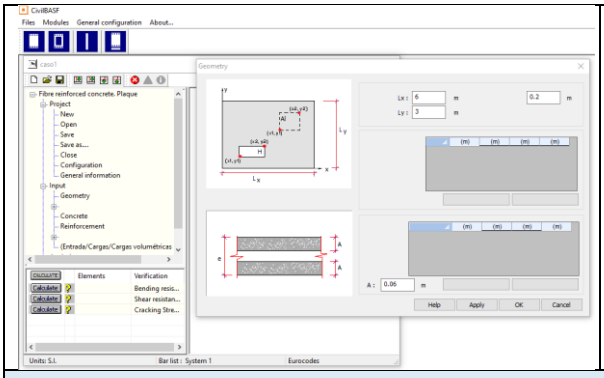
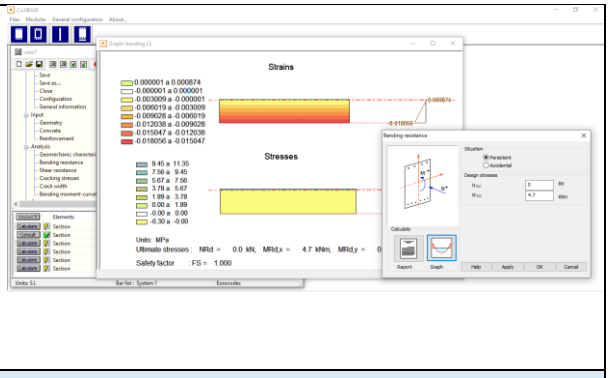




| Description of BIM USE | |
|---|---|
| Does the software use data from a BIM file? | No |
| What type of (BIM) files does the software need / will it be built for? | No BIM needs |
| Does the software generate data that can be added to a BIM file? | Yes, BIM models (construction products) |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | To be evaluated |

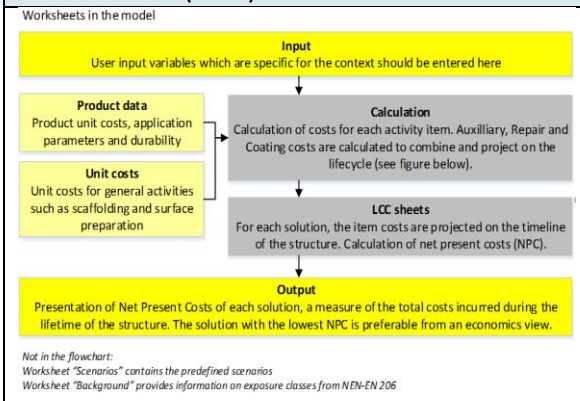
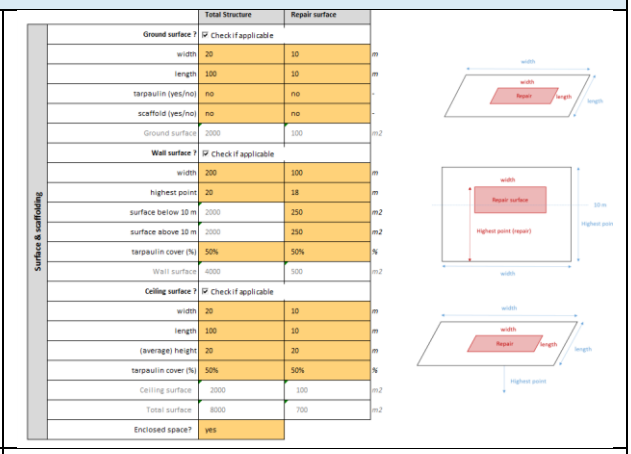
| | |
|---|---|
| Does the software generate/provide for any specific files and formats? |  |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | The OPT will be linked to SPHERE platform as an external tool to be used on-line.<br><br>https://www.online-planning.construction.basf.com/ |

# C5.3 Fiber Reinforced Concrete Tool (FRCT)

| Fiber Reinforced Concrete Tool (FRCT) | Logo if available |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | The main goal is the partial or full replacement of steel rebar in precast concrete elements and concrete slabs-on ground by using polypropylene fibers. TRL level to be provided. |
| How is the software tool to be used and by whom? | The tool is intended for architects, engineers, BIM managers, construction managers and contractors during the concept design and construction assembly phase |
| What does the end user get from using the software tool in terms of results? | Provides a constitutive model that enables to develop a computer aided tool for Nonlinear Fibre Reinforced Concrete Designs. Allows for developing new designs for FRC precast façade panels and slabs, in which the traditional steel reinforcement is totally or partially replaced. |
| What are the main benefits from the results provided by the software tool? | As an **architect and engineer** it will help me to carry out structural checking of specific concrete elements , using polypropylene fibers (more sustainable materials) to replace traditional reinforcement. As a **BIM Manager** it will help me to refine my BIM models in the BIM Building Design. As a **Construction Manager** or **Contractor** it will help me to evaluate the total replacement or partial replacement of steel reinforcement in façade panels and slabs -> cost benefits, sustainability impact. |
| Which SPHERE sub-modules does the software relate to? | I5.M1.SM2 |
| **Screenshots (four)** | |

| | |
|---|---|
|  |  |
| Description of BIM USE | |
| Does the software use data from a BIM file? | No, |
| What type of (BIM) files does the software need / will it be built for? | No needs |
| Does the software generate data that can be added to a BIM file? | Yes, it does. |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | The user enters manually the shape of the concrete element (i.e. precast panel) |
| Does the software generate/provide for any specific files and formats? | ifc files |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | To be discussed: linked to SPHERE platform as an external tool or integrated in the platform. |

# C5.4 Life Cycle Cost Concrete Assessment (LCCCA)

| Life Cycle Cost Concrete Assessment (LCCCA) | |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | Tool (excel file) to compare and find a proper solution to protect and repair reinforced concrete structures on the basis of life cycle costs Technological maturity level (TRL) |
| How is the software tool to be used and by whom? | The tool is intended for construction managers, architects and engineers, and contractors during the Strategic Definition and Design Phase |
| What does the end user get from using the software tool in terms of results? | Compare different solutions of repair and coating on the basis of Life Cycle Costs (LCC) and Life Cycle Environment Assessments (LCA). This model is used to compare BASF solutions of repair and coating on the basis of Life Cycle Costs (LCC) |
| What are the main benefits from the results provided by the software tool? | As a **Construction Manager, Architect or Engineer or Contractor** I will obtain a solid economic foundation to select the best repair/coating solution for a specific situation. In addition, the service life of a product determines the interval for re-application and thus greatly influences lifecycle costs. By protecting the initial repair with a coating which is re-applied as specified, initial costs may be higher but service life of the repair may greatly increase. Thus, the application of coating determines the costs for re-application and may decrease Life Cycle Costs |
| Which SPHERE sub-modules does the software relate to? | I3.M2.SM3; I5.M1.SM1; I5.M1.SM2 |
| **Screenshots (four)** | |
|  |  |
| | |
| **Description of BIM USE** | |
| Does the software use data from a BIM file? | No |
| What type of (BIM) files does the software need / will it be built for? | No needs |
| Does the software generate data that can be added to a BIM file? | No |
| | |

| Description of other DATA | |
|---|---|
| What other datasets are needed from other tools or entered by the user? | No need |
| Does the software generate/provide for any specific files and formats? | In sheet "Output" the results are shown, as the calculated Life Cycle Costs of each solution. This is a measure of the total costs incurred during the lifetime of the structure. The solution with the lowest LCC should be selected from an economic point of view. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | We should try to link excel file to BIM software (i.e. Revit) |

## C.6 R2M – En-MS

# C6.1 Energy Management System (En-MS)

| Energy Management System (En-MS) | Not yet Available |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | Tool including energy audit workflows, providing a energy planning process, objectives & targets that can be tracked, and supporting the Energy Review identifying the energy sources and related significant energy uses together with estimation of possible improvement opportunities. Technological maturity level (TRL) still to be defined |
| How is the software tool to be used and by whom? | Visible service for Design Team, Building Automation Team, MEP Engineer, Building Facility Manager, Tenant. To be used in Strategic Definition and in-use phaseas part of implementing an Energy Management system (ISO 50001) in the building |
| What does the end user get from using the software tool in terms of results? | EnMs web platform/application - to be agreed with VRM. For implementation of energy Management system |
| What are the main benefits from the results provided by the software tool? | Improvement of energy efficiency in the building – improvement of quality in the management of the building. Economic savings from energy efficiency improvement. |
| Which SPHERE sub-modules does the software relate to? | I2.M1.SM3<br>I5.M2.SM6 |
| **Screenshots (four)** | |
| Not yet available | |
| **Description of BIM USE** | |
| Does the software use data from a BIM file? | To be studied Data needed related to energy consumption, building physics data and data related to KPIs |
| What type of (BIM) files does the software need / will it be built for? | To be studied |
| Does the software generate data that can be added to a BIM file? | To be studied |
| **Description of other DATA** | |
| What other datasets are needed from other tools or entered by the user? | Energy consumption data, KPI, building physics data, data from energy audit, target and objectives |
| Does the software generate/provide for any specific files and formats? | To be studied |
| **Service Architecture** | |
| How would the software interface with the SPHERE platform? | Cloud based API |

## C.7 EAI - ECOSIMPRO

# C7.1 ECOSIMPRO

| EcosimPro | EcosimPro Modelling and Simulation Software |
|---|---|
| Software Overview | |
| What is the purpose of the software tool within the context of the SPHERE platform? | EcosimPro is a first class modelling and simulation tool for modeling 0D or 1D multidisciplinary continuous-discrete systems and any kind of system based on differential-algebraic equations (DAE) and discrete events. EcosimPro has been designed to carry out steady state and transient studies, as an optimization and design tool that helps the engineer to improve any kind of system modeled with equations (0D and 1D). It also provides a highly intuitive graphics environment that facilitates its use in creating physical models based on schematic views. Within SPHERE platform it will be used to model and simulate the building and its HVAC system including control to support energy assessment, design verification, and optimization of the operation.<br>The technological maturity level of the simulation platform is TRL9, having being used in aerospace and energy areas for many years. |
| How is the software tool to be used and by whom? | EcosimPro is a desktop software tool including a result visualization module (EcosimPro monitor). The user can perform different simulation analysis, post process the results and export them in different ways. It is also possible to generate standalone applications from simulation models generated with EcosimPro if necessary. The tool provides interfaces with FMI, OPC UA and Matlab/Simulink for cosimulation and SIL and HIL applications.<br>End users will be engineers responsible for the HVAC design, the building automation team, facility managers and maintenance companies.<br>Given its generalist approach can be used from design phase to operation for different purposes.<br>In the design phase, it will be used by HVAC engineers to analyse the design alternatives and control strategies to optimize the performance. Building automation teams may use the simulation models for the virtual commissioning of the system. During operation phase, facility managers and maintenance companies can use the model generated to analyse the baseline operation, evaluate alternatives and detect problems comparing simulation results with measured data from sensors. |
| What does the end user get from using the software tool in terms of results? | EcosimPro can store result files in different formats like ASCII, csv and hdf5. For standalone applications, the results can be obtained by executing the standalone application step by step.<br>The results provided include physical variables like pressure, temperature, massflow, heat flows and other relevant variables. |

| | |
|---|---|
| What are the main benefits from the results provided by the software tool? | Allowing the functional assessment of the HVAC system for different purposes: design analysis, performance optimization, detection of malfunctions, etc. |
| Which SPHERE sub-modules does the software relate to? | I1.M4.SM4: HVAC Library<br>I1.M4.SM5: Thermal and fluid component libraries<br>I3.M1.SM3: Heat load modelling<br>I3.M1.SM4: Renovation energy assessment<br>I4.M5.SM1: Comparison of energy simulation values and real values<br>I5.M2.SM3 Energy use optimization |

Screenshots (four)

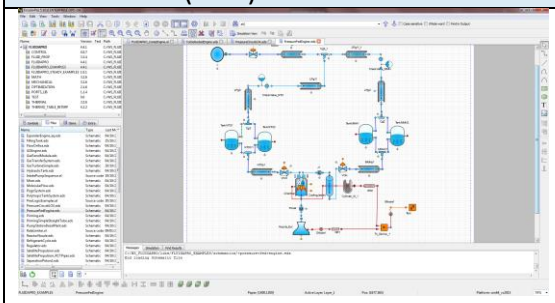


**Figure 42** EcosimPro GUI for schematic diagram edition

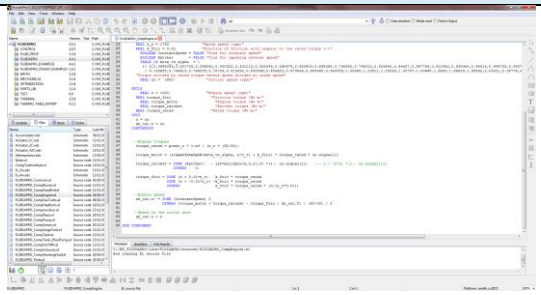


***Figure 43*** *EcosimPro development environment*

**Figure 44** EcosimPro tool for results visualization

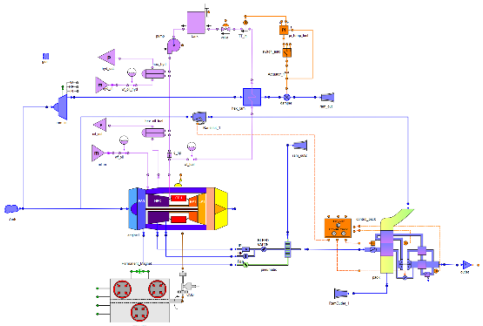


**Figure 45** Example of EcosimPro model of engine and aircraft systems

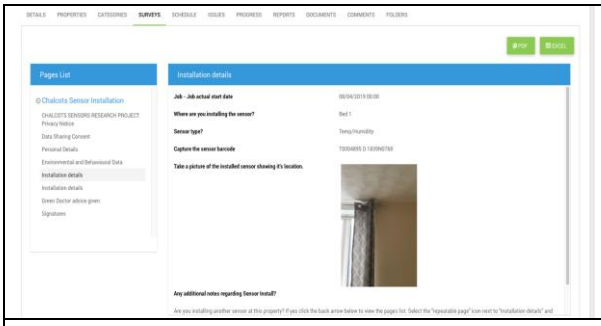
| Description of BIM USE | |
|---|---|
| Does the software use data from a BIM file? | Yes, If the scope of the model includes the building it is required to import the building geometric information and its parameters. Similarly, it is also necessary to incorporate the information related with the equipment used for the HVAC system. |
| What type of (BIM) files does the software need / will it be built for? | IFC |
| Does the software generate data that can be added to a BIM file? | No. |
| Description of other DATA | |

| | |
|---|---|
| What other datasets are needed from other tools or entered by the user? | Other files used are: weather files (TMY), files related with information not included in IFC, e.g. those related with assets (to be defined) or heat load data from other software tools. |
| Does the software generate/provide for any specific files and formats? | The software can provide simulation results in different formats (ASCII, csv, hdf5) |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | API for data importation and results exportation |

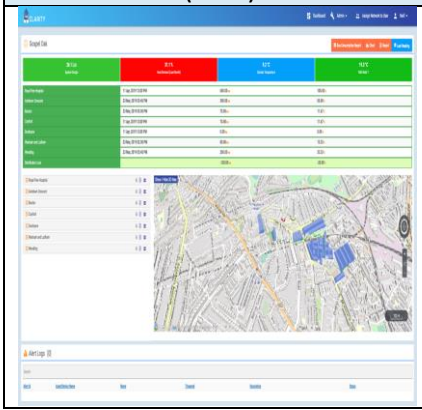
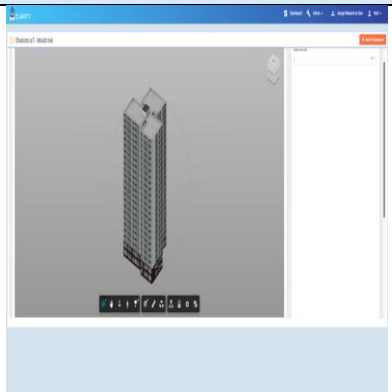
## C.8 VRM – Refurbify & Clarity

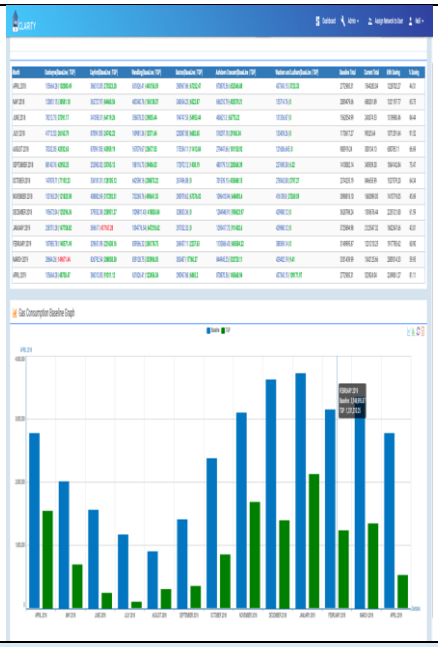
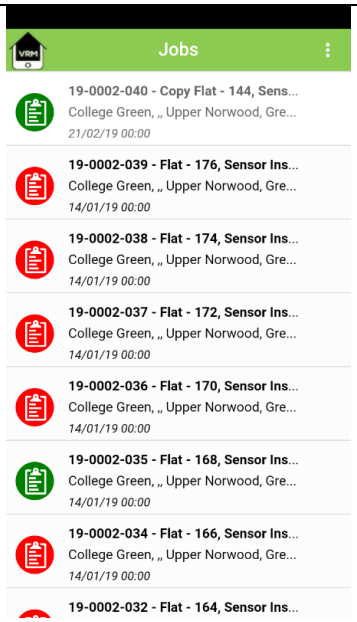
# C8.1 Refurbify + VCMP

| **Refurbify + VCMP** |  |
|---|---|
| Software Overview | |
| What is the purpose of the software tool within the context of the SPHERE platform? | VRM Refurbify is a cloud-based refurbishment platform enabling large housing stockowners and their supply chain to manage all refurbishment, repair and maintenance activities seamlessly in the cloud. The technological maturity level of the platform is TRL7-9 depending on the application.<br><br>Refurbify also has a sub-module called the VCMP (Virtual Construction Management Platform) that is used for the same process during the construction phase |
| How is the software tool to be used and by whom? | It is a service with an interface that is used by Social Landlords, Construction Bodies, and Regulatory Bodies, and used during the renovation phase and for handover, as well as in the in-use phase for maintenance. |
| What does the end user get from using the software tool in terms of results? | The user is provided with i) Integrated tendering solution. Allows tenderers to grant access to potential contractors to review available data in detail. Access to BIM models where available, ii) Platform designed with intuitive, visually-focussed and configurable KPIs. Minimal training should be required, iii) Auto-generate alerts and graphics for end-user/stakeholders/residents allowing at-a-glance information on energy saved and/or consumed, iv) Reduced snags as desktop approvals happen in real-time or near-time. Payment approvals are linked to agreed and approved work items with required digital evidence. Less reasons not to pay. Client can have visibility through main contractor down to sub-contractor level. |
| What are the main benefits from the results provided by the software tool? | The main benefits are an efficient and timely communication and information flow between different parties working on a renovation both between off-site and on-site personnel, resulting in large cost savings over standard non-streamlined approaches. |
| Which SPHERE sub-modules does the software relate to? | I1.M1.SM1;I1.M1.SM2;I1.M2.SM1;I1.M2.SM2;I1.M2.SM3; I1.M3.SM1; I1M5.SM1; I4.M1S.SM2; I4.M2.SM1;I4.M2.SM2 I4.M6.SM1;I5.M1.SM1;I5.M1.SM3 |
| Screenshots (four) | |

| | |
|---|---|
|  | |
| | |
| Description of BIM USE | |
| Does the software use data from a BIM file? | Yes it utilises BIM with an integrated BIM viewer for understanding specific building elements within renovation process needs |
| What type of (BIM) files does the software need / will it be built for? | Can work with both IFC and gbXML |
| Does the software generate data that can be added to a BIM file? | No |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | Renovation Documents, Photo's, task listings |
| Does the software generate/provide for any specific files and formats? | No specific files, all done via interfaces |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | - Data Inputs:<br>• Encrypted JSON payload<br>• REST API for Refurbify <> Clarity interface. FTPS<br>• CSV/flat file<br>• external API (Environmental data)<br>- Data outputs:<br>• FTPS transfer to client<br>• CSV/flat file.<br>- Database and repository specific information<br>• Database type: MySQL<br>• Size: Variable (consistently large dataset)<br>• Location: AWS |

# C8.2 Clarity

| | |
|---|---|
| Clarity | |
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | VRM Clarity is a networked Asset Hub, taking data from assets, BMS, sensors, onsite workers, residents and back-office staff to provide an objective view of assets through configurable Dashboards. The technological maturity level of the platform is TRL 7-9 |
| How is the software tool to be used and by whom? | It is a visible service for Construction companies, renovation companies, Facility Managers, Building Owners and it is used in the in-use cycle of the product. |
| What does the end user get from using the software tool in terms of results? | The end users obtains visibility of the internal performance of the building in a wide range of areas, including energy, ventilation, and indoor environmental quality, that can be integrated with a Building Maintenance System. |
| What are the main benefits from the results provided by the software tool? | The software provides savings up to 30%-40% due to lower energy and maintenance cost, reduction of OPEX by changing from reactive to proactive maintenance, reduction in CAPEX due to extended asset life of HVAC equipment. |
| Which SPHERE sub-modules does the software relate to? | I1.M3.SM2; I1.M3.SM3; I1.M3.SM4; I1.M3.SM5 |
| **Screenshots (four)** | |
|  |  |

| | |
|---|---|
|  |  |
| Description of BIM USE | |
| Does the software use data from a BIM file? | Yes, for locating/placement of sensors within a property within a BIM viewer |
| What type of (BIM) files does the software need / will it be built for? | IFC |
| Does the software generate data that can be added to a BIM file? | Yes sensor elements |
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | None |
| Does the software generate/provide for any specific files and formats? | Yes time-series data associated with sensors. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | Cloud based API |

## C.9 NUIG - ModSCO

# C9.1 ModSCO

| ModSCO | |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | ModSCO is the acronym for Model-Supported Control. This is a web application currently in development within the IRUSE group at the NUIG. ModSCO uses Reduced Order Grey Box Models (ROM) developed with MODELICA ® language. It offers standardized Performance Assessment Methods in order to analyse and optimize building performances by: applying control settings, testing envelope retrofit packages and evaluating the savings by using a novel IPMVP method. The technological maturity level is 4. |
| How is the software tool to be used and by whom? | It is a visible service for MEP engineers, Maintenance Service Companies, Certified Measurement and Verification Professiona and Building Facility Managers, to be used in Preparation and brief, Concept design, In-use phase<br><br>Used to develop quick model of a building and have a quick evaluation of the performance. Generate energy conservation opportunity Correct operation of HVAC systems, monitor energy conservation opportunities, correct operation of HVAC systems.<br>Analyse ideal (generated by the ROM) vs actual performance of a building following the M&V protocol. Optimize the HVAC setting by comparing the real data with the baseline model (generated by the ROM) Apply building retrofitting scenarios (envelope) |
| What does the end user get from using the software tool in terms of results? | ModSCO is based on a Python code. It gives as result .csv files and related graph. Mainly Gas and electricity consumption of the building/room. Other output could be taken from the Modelica model such as cooling and heating pick of energy, average temperature of the building. |
| What are the main benefits from the results provided by the software tool? | ModSCO simplify the building energy simulation by giving an easy to setup interface, a fast to run simulation and accurate results that can support impact evaluation of environmental and energy retrofit scenarios using a limited information and uncertain data. |
| Which SPHERE sub-modules does the software relate to? | *I3.M1.SM3, I3.M1.SM4, I5.M2.SM3* |
| **Screenshots (four)** | |

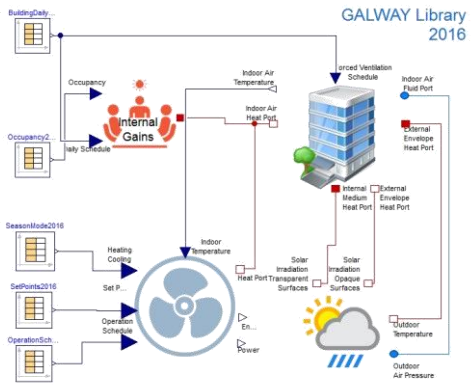



**Figure 46** - Modelica Model

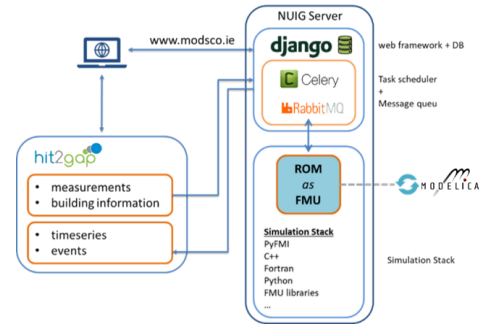



**Figure 47** - ModSCO application architecture

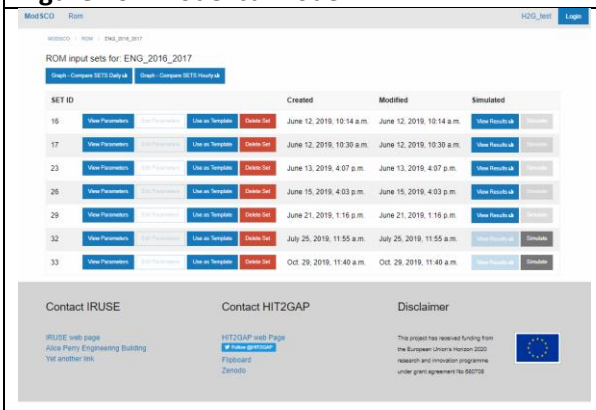



**Figure 48** - ModSCO web user interface

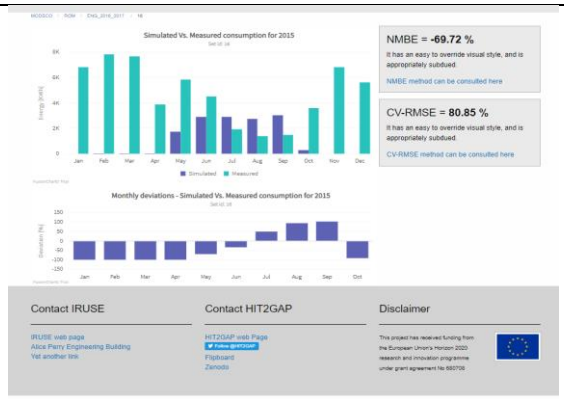



**Figure 49** - ModSCO Results example

| **Description of BIM USE** | |
|---|---|
| **Does the software use data from a BIM file?** | Not yet. The BIM data could speed up the parameter's insertion. All the building envelope characteristics are needed, they will simplify the resistances and capacitances calculation. |
| **What type of (BIM) files does the software need / will it be built for?** | IFC |
| **Does the software generate data that can be added to a BIM file?** | No. |
| **Description of other DATA** | |
| **What other datasets are needed from other tools or entered by the user?** | The data needed is<br>the building latitude (**Latitude**),<br>the building total volume [$m^3$] (**Volume**),<br>the windows surfaces for each direction [$m^2$] (e.g. **AWin$_{xxx}$**)<br>the g total value of the windows for each direction (e.g. **GtotW$_{xxxx}$**)<br>the ratio between a building element surface and the total building surface (e.g. **Ratio_$_x$**)<br>the resistances and capacitances, automatically calculated with the buildings specs(e.g. **C$_{xxx}$**, **R$_{xxxx}$**)<br>infiltration rate (**L_RATE**)<br>Weater file(**WeaFile**) |

Ground Temperature (**GroundT**)
maximum people, lighting and equipment heat gain (e.g. **MLoad$_{xxx}$**)
standby value of equipment heat gain (**SBLoad**)
Maximum HVAC cooling and heating power(**MCoolP, MHeatP**)
the stand-by consumption of the HVAC(**SBHC**)
thermostat hysteresis range(**Trange**)
people to switch off/of control (**P$_{_SWITCH}$**)
Finally the Alpha parameters that are used in the calibration process ( thay start with a value equal to one)

In the following Table the full list of ROM parameters is provided.

**Table 39**- ROM Parameters

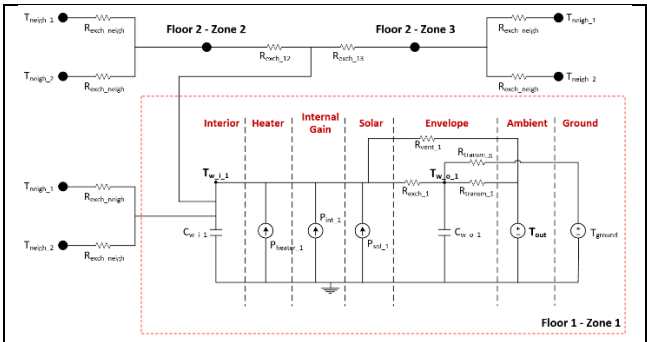
| | Value | Unit | | Value | Unit |
|---|---|---|---|---|---|
| **Latitude** | 41.4776 | - | **$R_M$** | 1.17E-04 | K/W |
| **Volume** | 13547 | $m^3$ | **$C_M$** | 2.52E+09 | J/K |
| **$AWin_{South}$** | 255.75 | $m^2$ | **$R_{GF\_IS}$** | 6.57E-05 | K/W |
| **$AWin_{North}$** | 237.51 | $m^2$ | **$R_{GF}$** | 2.83E-04 | K/W |
| **$AWin_{West}$** | 60.9 | $m^2$ | **$R_{GF\_ES}$** | 2.02E-05 | K/W |
| **$AWin_{Est}$** | 54.81 | $m^2$ | **$C_{GF}$** | 1.51E+09 | J/K |
| **$AWin_{Roof}$** | 0 | | **L$_{_RATE}$** | 3 | Kg/s |
| **$GtotW_{South}$** | 0.75 | - | **WeaFile** | SanCugat | - |
| **$GtotW_{North}$** | 0.75 | - | **GroundT** | 20 | °C |
| **$GtotW_{West}$** | 0.75 | - | **$MLoad_{Peo}$** | 32756 | W |
| **$GtotW_{Est}$** | 0.75 | - | **$MLoad_{Lig}$** | 42280 | W |
| **$GtotW_{Roof}$** | 0 | - | **$MLoad_{Eqi}$** | 6724 | W |
| **Ratio$_{_m}$** | 0.381 | - | **SBLoad** | 0 | W |
| **Ratio$_{_wall}$** | 0.424 | - | **$Alpha_{Lig}$** | 1 | - |
| **Ratio$_{_win}$** | 0.046 | - | **$Alpha_{Eqi}$** | 1 | - |
| **Ratio$_{_gf}$** | 0.149 | - | **MCoolP** | XX | W |
| **$R_{WALL\_IS}$** | 2.31E-05 | K/W | **MHeatP** | 345000 | W |
| **$R_{WALL}$** | 1.02E-03 | K/W | **SBHC** | 10000 | W |
| **$R_{WALL\_ES}$** | 7.10E-06 | K/W | **Trange** | 1 | °C |
| **$C_{WALL}$** | 1.18E+09 | J/K | **P$_{_SWITCH}$** | FALSE | - |
| **$R_{WIN\_IS}$** | 2.13E-04 | K/W | **$Alpha_{Peo}$** | 1 | - |
| **$R_{WIN}$** | 6.33E-04 | K/W | **$Alpha_{Heat}$** | 1 | - |
| **$R_{WIN\_ES}$** | 6.56E-05 | K/W | **$Alpha_{Cool}$** | 1 | - |
| **$R_{M\_IS}$** | 2.56E-05 | K/W | | | |

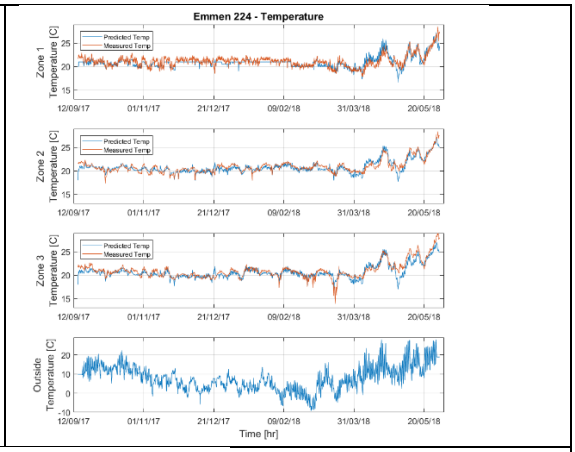
| | |
|---|---|
| **Does the software generate/provide for any specific files and formats?** | The script is developed by using Python. Several kinds of files can be generated. At the moment they are mainly .csv |
| **Service Architecture** | |
| **How would the software interface with the SPHERE platform?** | Cloud based interface API |

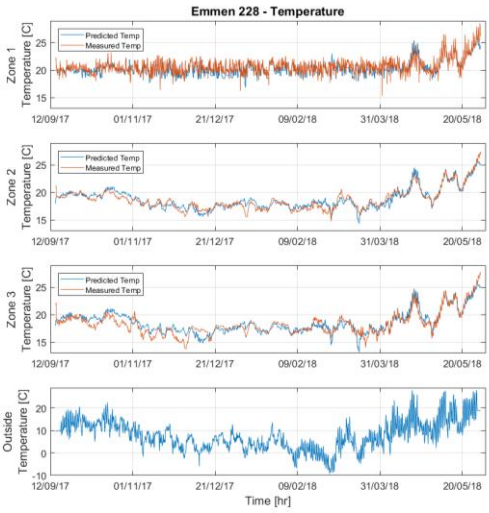
## C.10 TNO - RobMOS

# C10.1 RobMOS

| ROBMOS | |
|---|---|
| Software Overview | |
| What is the purpose of the software tool within the context of the SPHERE platform? | The goal of this tool is to better predict energy demand and IEQ (thermal comfort) of dwellings. The tools is able to continuously calibrate its models with real data reducing the gap between predicted energy demand and monitored energy demand. The tTechnological maturity level (TRL): TRL: 6 |
| How is the software tool to be used and by whom? | It is a service for project engineer responsible for calculating energy performance and IEQ in the design phase, and the project engineer responsible for checking performance contracts energy and IEQ in the use phase. In the design phase, the tool reads in the gbXML file of the dwelling, and compiles this to a building energy demand model and building thermal model, additional data is provided regarding lacking building data (for example airtightness) and installation information (system performance, buffers, type of systems). After specifying a climate scenario and occupant use scenario, a simulation can be started. KPIs can be derived from the simulation outputs. In the use phase the model is calibrated with real monitoring data and the performance can be compared with the performance according to the design. |
| What does the end user get from using the software tool in terms of results? | The user obtains time series (vectors) of simulation outputs. Single values (scalars) of KPIs on energy and thermal comfort. Time series of temperatures per zone. Time series of heating cooling power. KPIs of energy performance and thermal comfort.<br>Prediction and comparison with energy use according to design with calibrated models of the real dwellings. |
| What are the main benefits from the results provided by the software tool? | Performance benefits include at an early stage of the buildings life cycle, estimations of the future energy performance and thermal comfort can be calculated. During the operational stage of the life cycle, the performance of the building can be compared with the simulated performance. In case of (significant) deviations, a trigger signal can be sent to either tenant or building manager. The cost/financial benefits include that the tool allows design optimizations, preventing the need to compensate for design mistakes during the building phase. Furthermore, tenants and maintenance companies or ESCO's can be informed in case of errors in HVAC installations, HVAC usage or building envelope. |
| Which SPHERE sub-modules does the software relate to? | Sub-module or modules listing<br>I1.M4: BIM and objects libraries module<br>I3.M1: Energy modelling and simulation module.<br>I4.M5: Commissioning<br>I5.M2: Energy management and performance monitoring |
| Screenshots (four) | |



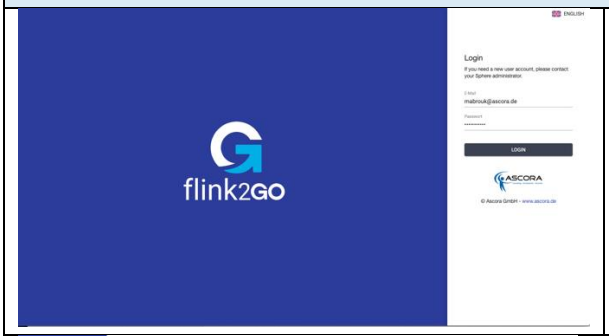
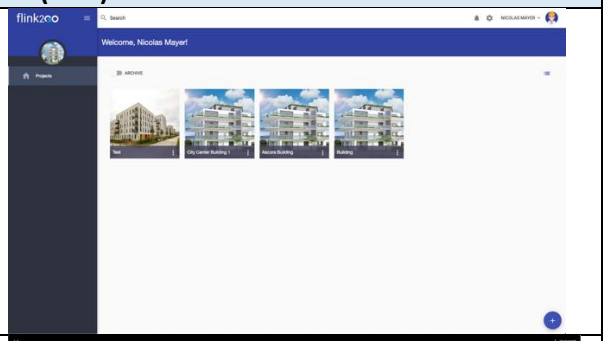
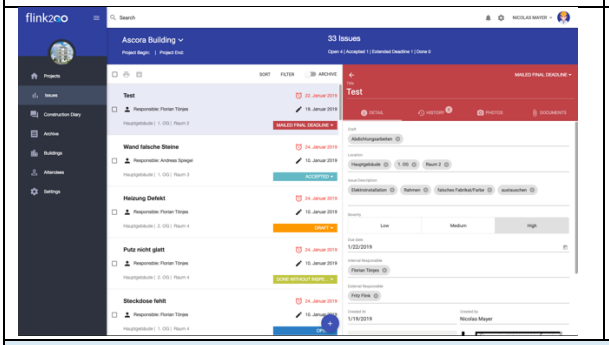

| Description of BIM USE | |
|---|---|
| Does the software use data from a BIM file? | Yes, data requirements include:<br>Description of building (preferably gbXML model)<br>Dimensions and construction parameters (mass, Rc, U, airtightness): roof, façade, windows, blinds, walls, and floor<br>Location / orientation of building<br>Building structure: zones, special orientation (heated, not heated)<br>Heating / cooling system / ventilation system (type, efficiency, performances, capacity). Other relevant systems |
| What type of (BIM) files does the software need / will it be built for? | The software uses gbXML file formats and is used for calibrating: Monitoring data (preferably 15 minutes – hour values), ontology Project HayStack:<br>Temperatures (living room, bedroom). Energy usage (separate domestic hot water, heating/cooling, appliances, auxiliary energy, PV). Weather data (from nearby weather station). Occupancy data (presence #, schedule, preferable window use)<br>Thermostat values, ventilation control (setpoints) |
| Does the software generate data that can be added to a BIM file? | No |

| | |
|---|---|
| Description of other DATA | |
| What other datasets are needed from other tools or entered by the user? | gbXML description of dwelling<br>additional building information not in IFC<br>Models of HVAC components<br>Climate models (design phase)<br>User scenarios (design phase)<br>Monitoring data see above (use phase) |
| Does the software generate/provide for any specific files and formats? | Simulation results are stored as CSV files. |
| Service Architecture | |
| How would the software interface with the SPHERE platform? | Preferably via an API. Also files exchange can be managed via an API. At this stage, however, it is still difficult to know what information will be present in the SPHERE platform. Manual use with data files<br>The tool can also operate without the SPHERE platform. |

## C.11 ASC – FLINK2GO

# C11.1 FLINK2GO

| Flink2Go | flink2GO |
|---|---|
| **Software Overview** | |
| What is the purpose of the software tool within the context of the SPHERE platform? | Brief description<br>Flink2Go is a B2B product resulting from the research project ACCEPT. It's a cloud based platrom which brings paperless solutions to the construction site enabling reporting issues and assigning tasks with a construction diary and defects management, supporting the Building Information Model (BIM) and keeping records for proving correct accounting. Fine grained user roles and usage rights can be set for users of the tool.<br>Technological maturity level (TRL) - TRL 6 |
| How is the software tool to be used and by whom? | Is it an application (hidden) or a visible service?<br>Visible Service: Flink2Go is a cloud based platform with an interface<br>End users:<br>Project Managers, Architects, Construction Managers, Construction sub-contractors, building owners, surveyor, tenants and maintenance facility companies.<br>Life cycle stage in which it is used:<br>Preparation and brief, Design phase, Construction and assembly, In-use Phase<br>Usage of product:<br>Project Managers can use the tool to add the project team and define their roles and responsibilities, and by having an overview on the overall status of the project. (Delayed tasks, urgent issues). Surveyors can upload any observed/collected information which may be relevant to the project to the platform (walkover survey outcome), initiate detailed site surveys focusing on specific issues, and save all the obtained information of the survey on the platform and shared among the concerned parties. Architects can Upload detailed iterations of the building drawings to the platform and receive feedback and identify any instructions required by the client/building owner. Building owners can preview the drawings and send feedback. Construction Leads can create tasks/issues, schedule them, assign them to the internal/external responsible and mark their location in the building (on the 2D drawing or the 3D model where available), and initiate approval directly on the Sphere platform to report/validate the subcontractors work. Maintenance Service companies can manage the building issues created by the tenants and assign them to the responsible Maintenance Service Company |
| What does the end user get from using the software tool in terms of results? | The user will mainly profit from the simplicity of issue reporting/ task assignment, as Flink2Go will allow a direct communication between the on-site operatives and the backend office. This will reduce the time needed to get approval from the decision makers. The user will also gain more time with tailor-made text modules and intelligently pre- |

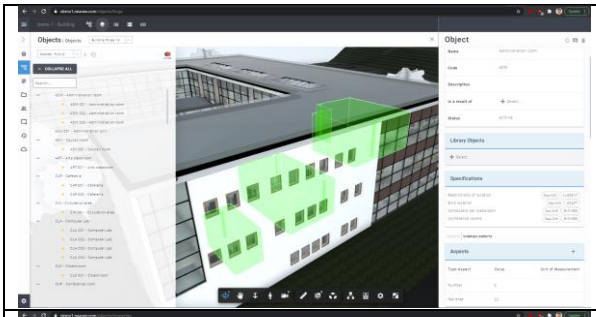
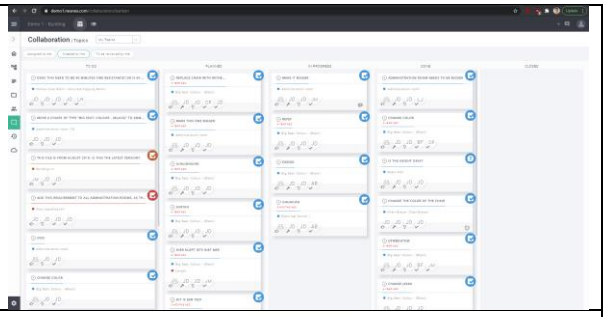
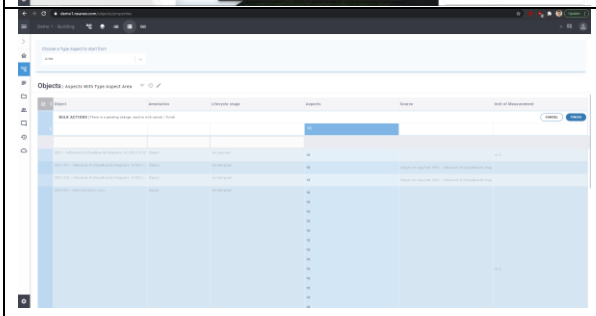
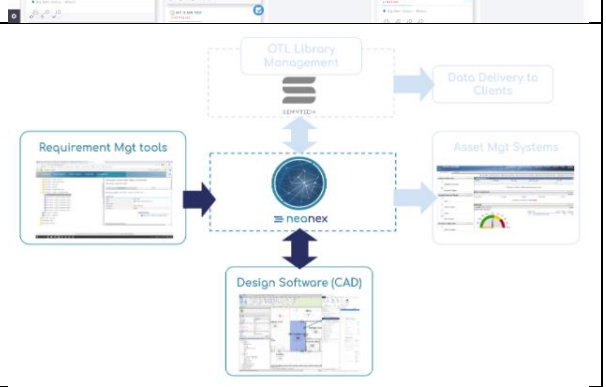
| | |
|---|---|
| | filled entries which reflect how the platform has been designed to be super user friendly with no training required. |
| What are the main benefits from the results provided by the software tool? | -Saving time in defects/issues reporting and recording between the front and back office => Time saving in communication => Efficiency and cost saving.<br>-Error reduction in logging<br>-Automation of documentation |
| Which SPHERE sub-modules does the software relate to? | I1.M1.SM2 Create Project & Identify Roles<br>I1.M2.SM2 Roles and Processes Matching<br>I1.M2.SM3 Authorisation<br>I1.M3.SM4 Dynamic Data Visualisation<br>I4.M2.SM1 Site Role/Task Management<br>I4.M2.SM2 Site Surveys and Inspection<br>I4.M2.SM4 Progress Monitoring<br>I5.M1.SM3 Building Issue Management |
| **Screenshots (four)** | |
|  |  |
|  |  |
| **Description of BIM USE** | |
| Does the software use data from a BIM file? | Yes - Using BIM data to visualize the geometry and attach task/issues to correspondent BIM element |
| What type of (BIM) files does the software need / will it be built for? | IFC |
| Does the software generate data that can be added to a BIM file? | No |
| **Description of other DATA** | |
| What other datasets are needed from other tools or entered by the user? | Description of other data requirements:<br>Project and Team information<br>Sub-Contractors Information<br>Photos |

| | |
|---|---|
| | 2D plans (if no BIM data avaialble) |
| Does the software generate/provide for any specific files and formats? | Description of files generated?<br>Reports (inspection, survey, issues) in a PDF format.<br>Annotated 2D plans in a PDF format |
| **Service Architecture** | |
| How would the software interface with the SPHERE platform? | - Data Inputs:<br>IFC<br>REST API<br>CSV (Project settings import)<br>- Data outputs:<br>CSV<br>REST API<br>- Database: MongoDB database hosted on Hetzner |

## C.12 NEXT – Neanex Portal

# C12.1 Neanex Portal

| Neanex Portal | neanex<br>think as many - work as one |
|---|---|
| **Software Overview** | |
| **What is the purpose of the software tool within the context of the SPHERE platform?** | The Neanex Portal will function as an asset register, managing the static & geometric data on a project basis. Because of its graph database structure, all tools can request very specific data for their needs. On the other hand, data can be enriched in the Neanex Portal by the different SPHERE tools, preparing the project data for handover to other parties compliant to certain standards (eg. COBie, NLSfB, ...). |
| **How is the software tool to be used and by whom?** | The Neanex Methodology envisages the entire project - the project team and stakeholders - during the entire life-cycle of a construction project. Typical customers include public and private owner-operators, architectural and engineering firms, contractors, project developers, etc… |
| **What does the end user get from using the software tool in terms of results?** | Smart and contextual data. All project members can easily share and access asset information in the context they require, so that it is specific and relevant for their tasks and interests. |
| **What are the main benefits from the results provided by the software tool?** | The Neanex Portal solves the top three pains in the construction industry:<br>- Data loss: the collaboration between different parties and the handovers in between create a lot of duplicate or corrupt data.<br>- Costs: the inefficient, manual (re)gathering of data, the errors as a result of corrupt data.<br>- Integrations: no interoperability between different tools of a construction project, no common data. |
| **Which SPHERE sub-modules does the software relate to?** | I1.M1.SM1 Identify Users<br>I1.M1.SM2 Create Project & Identify Roles<br>I1.M2.SM1 Setup and Management of Project Phases and Processes<br>I1.M2.SM2 Roles and Processes Matching<br>I1.M2.SM3 Authorisation<br>I1.M3.SM1 Data/Document Management<br>I1.M3.SM3 Exporting/Allow Access/Deletion of Data and Documents<br>I1.M3.SM4 Dynamic Data Visualisation<br>I4.M2.SM4 Progress Monitoring<br>I5.M1.SM3 Building Issue Management |
| **Screenshots (four)** | |


| Description of BIM USE | |
|---|---|
| **Does the software use data from a BIM file?** | Yes, geometric data is imported and related to asset data. Other BIM data can be interpreted and enriched through our own plugin: Neanex Connector. |
| **What type of (BIM) files does the software need / will it be built for?** | .rvt, .nwd, .ifc<br>Note that a lot of file types can be aggregated in Navisworks (.nwd) and imported through there. |
| **Does the software generate data that can be added to a BIM file?** | It can, BIM files can be enriched with data coming from the Portal. |
| **Description of other DATA** | |
| **What other datasets are needed from other tools or entered by the user?** | Nothing, the Neanex Portal is a standalone application. It only requires asset information coming from the project. |
| **Does the software generate/provide for any specific files and formats?** | The Neanex Portal can provide exports of data on demand. Usually this is through an API via JSON format. |
| **Service Architecture** | |
| **How would the software interface with the SPHERE platform?** | - Data Inputs:<br>4. .rvt, .nwd, .ifc for geometric data<br>5. REST API<br>6. csv/json<br>- Data outputs:<br>● REST API<br>● csv/json |