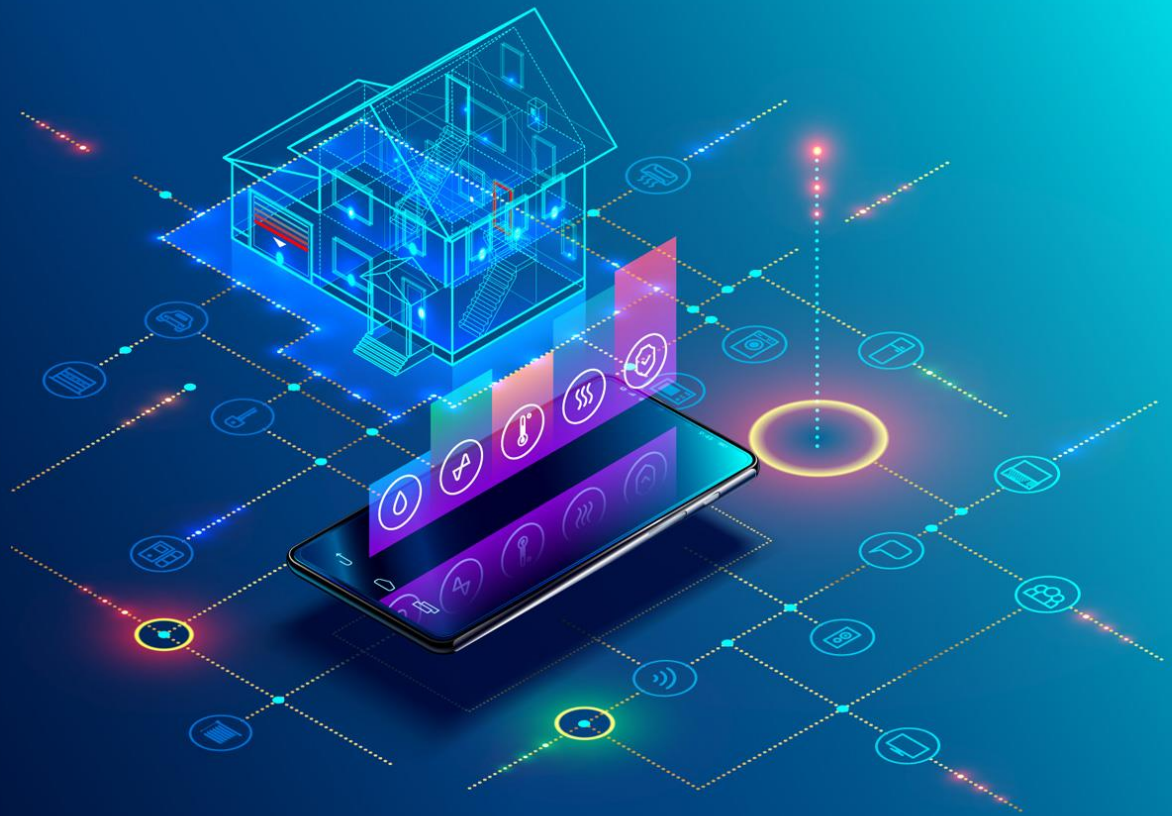# Full version of the BIMSPEED cloud platform, services, and interfaces

Deliverable Other D6.2

Deliverable Other D6.2: Final version, issue date on 31 October 2022

BIM-SPEED
Harmonised Building Information Speedway for Energy-Efficient Renovation

Disclaimer

Full version of the BIM-SPEED cloud platform, services, and interfaces

Issue Date	31 October 2022
Produced by	CSTB
Main author	Nicolas Pastorelly (CSTB)
Co-authors	Eric Pascual, Alan Redmond, Eric Gaduel (CSTB)
Version:	Final
Reviewed by	Samaneh Rezvani (DEMO), Sonia Álvarez Díaz (CARTIF)
Contributors:	TUB,CARTIF,HTV,CYPE,MTB
Approved by	Timo Hartmann
Dissemination	Public
Type:	Other

Colophon

Change log

Description	Author	Date
Initial version for internal review	Nicolas Pastorelly (CSTB)	29.9.2022
Internal reviewing	Samaneh Rezvani (DMO)	18.10.2022
Internal reviewing	Sonia Álvarez Díaz (CARTIF)	21.10.2022
Addressing internal review comments	Nicolas Pastorelly (CSTB)	21.10.2022
Internal reviewing	Timo Hartmann (TUB)	24.10.2022
Internal reviewing	Samaneh Rezvani (DMO)	30.10.2022
Addressing internal review comments	Nicolas Pastorelly (CSTB)	31.10.2022
Finale editorial review	Timo Hartmann (TUB)	02.11.2022

Publishable executive summary

Deliverable D6.2 describes the final version of the BIM-SPEED cloud platform, the main architectural component of the BIM-SPEED solution to speed up and increase the effectiveness and efficiency of BIM for renovation projects.

The BIM-SPEED cloud platform relies on the KROQI platform, a BIM collaborative cloud platform developed by CSTB at the request of the French public authorities to provide stakeholders, especially small entities (SMEs, VSEs), with tools allowing them to participate in the digital transition of the construction sector.

The BIM-SPEED platform relies on the KROQI platform in the way that it is using its infrastructure and pre-existing technical assets. Since KROQI is in exploitation phase, at M6, BIM-SPEED users were able to use a configured stable platform soon in the project, to understand its features and conscientiously expose requirements that were integrated during the project. The BIM-SPEED project has extended the KROQI platform by providing new technical features like "advanced services profiles" (to segregate BIM-SPEED services from KROQI default services see §4.2) and "workflows" (to coordinate BIM-SPEED services see §4.4). **At the end of the project more than 20 functional renovation-oriented services have been integrated & used on the BIM-SPEED platform (see §). Interoperability features and services from WP5 have been integrated into the platform to ease data exchange** (e.g., IFC4Acoustic parser service from CARTIF).

The KROQI platform had to be adapted to the specific needs of the BIM-SPEED project: it has been fully translated in English, and a profiling feature has been added to personalize the KROQI workspace dedicated to projects created in BIM-SPEED. This feature allows administrators of the platform to specify the services that can be used in a given workspace, e.g., the BIM-SPEED workspace. Thus, BIM-SPEED users did only have access to the services integrated into the platform during the BIM-SPEED project and, conversely, these services were not visible by non-BIM-SPEED users.

The KROQI workspace dedicated to BIM-SPEED can be accessed at: BIM-SPEED.kroqi.fr

The architecture of the platform is shown below. The central components of the platform are a document management system and a collaboration suite (1). Integrated into the user interface of the document management system, BIM-SPEED services for renovation are made available. Construction+ (2) is the middleware platform aimed to manage the third-party services enrollment and their integration into the collaboration suite interface. A RESTful API (3) allows external services to interact with the collaboration suite features, for example to upload or retrieve documents, or add

tags and comments. During the project, BIM-SPEED third-party online services were integrated into the platform (6) and were able to consume platform web services to access and process documents. Similarly, desktop applications (7) took advantage of these web services to get integrated into the BIM-SPEED platform (e.g., Cype BIMServer.center proxy application). CSTB has integrated an online model checking service (4) in the core of the platform (see §4.8), **the list of services platform improvement can be found in section 4.** CSTB has also provided as initially-integrated services a file naming service and a free desktop application named eveBIM (5) which is a multi-scale model viewer (IFC, CityGML etc.).
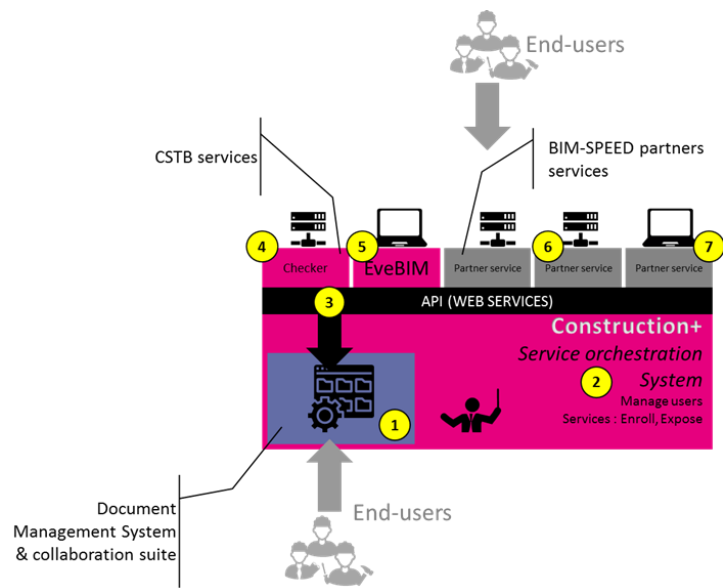
From an operational point of view, the BIM-SPEED workspace used for BIM-SPEED project collaborations is organised with the following projects:

- An **integration sandbox project** to exchange technical information and make tests with services developers;
- A **user support project** gathering all documents related to the "user experience" of the platform and providing user support;
- A **sample project** where any BIM-SPEED user can test and experiment BIM-SPEED collaboration and services;

BIM-SPEED pilot site projects where any partner in a renovation project can use the platform to carry out the project.

User accounts have been created for BIM-SPEED partners with specific privileges depending on the role they did play in the project. For instance, developers can access the integration sandbox project, and BIM-SPEED pilot site leaders can manage one (or several) pilot project(s) and invite anyone of their choice to this project space.

In terms of infrastructure, the data storage of the document management system and the collaborative suite is distributed on two datacenters located in France. A RAID 10 architecture, combining redundancy and data distribution, ensures optimal resilience of this infrastructure and prevents data corruption. In terms of privacy and integrity of data exchanges. As for the Construction + middleware, it is hosted on Google Cloud servers in Western Europe, and benefits from the security procedures specific to these cloud services. Besides, KROQI uses digital certificates based on SSL technology. These certificates make it possible to encrypt data during exchanges.

List of acronyms and abbreviations

ACL: Access Control List

API: Application Programming Interface

BCF: BIM Collaboration Format

BIM: Building Information Model

BPMN: Business Process Modelling Notation

CityGML: City Geography Mark-up Language

EDMS: Electronic Document Management System

EEB: Energy-Efficient Building

IFC: Industry Foundation Classes

MVD: Model View Definition

MvdXML: Model view definition XML

ORM: Object-Relational Mapping

RAID: Redundant Array of Independent Disks

RDF: Resource Description Framework

REST: Representational State Transfer

SDK: Software Development Kit

SME: Small and Medium-size Enterprise

SPARQL: SPARQL Protocol and RDF Query Language

SSL: Secure Socket Layer

SSO: Single Sign-On

VSE: Very Small Enterprise

XML: Extensible Markup Language

Definitions

KROQI

Name of the collaborative cloud platform developed by CSTB for the French construction stakeholders

eveBIM

Free multi-scale BIM viewer developed by CSTB, integrated in the KROQI platform

Triple store (or RDF store)

Database for the storage and retrieval of RDF triples through semantic queries

Docker

Virtualization technology allowing applications to be easily launched in software containers

List of figures

Contents

1. Introduction

A key aspect to speed up and increase the effectiveness and efficiency of BIM for renovation projects is to take advantage of a BIM Cloud Platform. The BIM-SPEED project uses the analogy of a Speedway. In contrast with the most available BIM solutions today, the development of the Information Speedway is based on a decentralised/cloud-based database structure and focus on developing interfaces that describe how data can be provided and obtained for and from various BIM tools. Such a cloud-based interface solution allows for a quick integration of different data available in different formats and databases while an interface layer ensures the consistency of the data provided at every 'Service Station' according to harmonisation standards that were developed in the project (open APIs and common data models from WP5). Such a micro-service strategy with a resilient infrastructure (see section 3.1) allows for the development of eco-systems of specialised applications to support different tasks for different stakeholders at the different 'Service Stations'. The R&D work within BIM-SPEED provides standards of how to exchange data between each of the 'Service Stations' to support the overall EEB deep renovation process.

The BIM-SPEED Information Speedway consists of 3 main elements (see figure 1):

1. **The BIM Cloud Platform** serves as an Information Speedway. It is not the 'final destination', but it is the holistic infrastructure that facilitates BIM-based processes, tools and data to achieve the short-term and long-term EEB deep renovation impacts. The 'Speedway' also contains 'traffic rules', which means: full compatibility standards, information exchange conventions, and agreements to regulate the workflows. The platform also manages the Data Storages.

2. The **10D BIM Toolset** can be considered as the 'Service Stations' along the Information Speedway. Each tool (each "Dimension of BIM") provides one or more functions to support EEB deep renovation, for example: As-Built Mapping, Modelling, Clash Detection, Scheduling, Cost estimation, Energy simulation, Comfort. The connections between the various BIM Tools and the BIM Cloud Platform are based on Open Interoperability principles.

3. The **BIM Projects and their Data** are like the vehicles and their content (passengers/goods) driving on the Information Speedway. Along the way, the vehicles and passengers receive the fulfilment of their needs at the 'Service Stations' (e.g. repair, refueling, restaurant). The BIM renovation project data is enhanced and enriched by the BIM Tools.
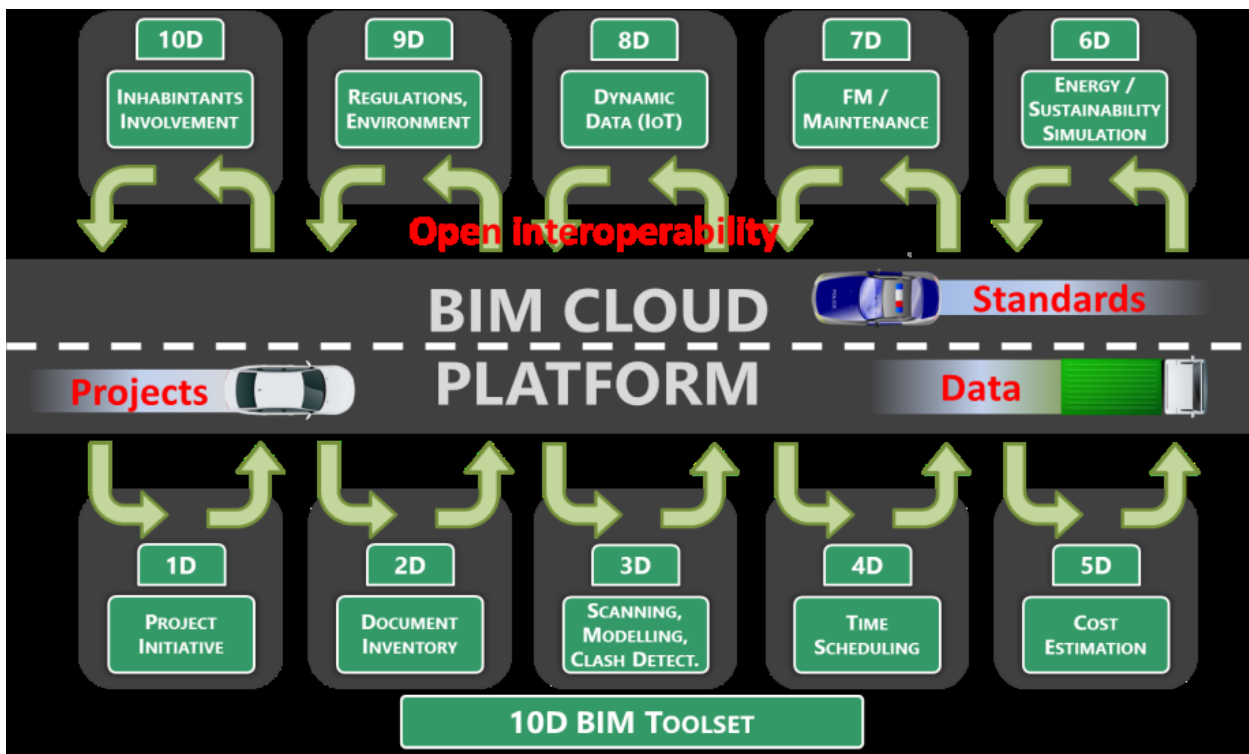
Figure 2.   BIM-SPEED Information Speedway concept

This deliverable presents the technical strategies and solutions chosen to implement the BIM-SPEED cloud platform and its released/tested features.

The final version of the BIM-SPEED cloud platform is an evolution of the launch version of the platform delivered at M6, thus the entire scope of platform's features & achievement will be presented in this document to present a relevant vision of the entire achievements to the reader.

The document introduces the KROQI platform developed by CSTB in the context of the French market (§2), provides an overview of the final technical BIM-SPEED platform (§3), then details some of the services and core improvements that have been produced during the project (§4). Finally, the document gives an overview of the platform account organisation used during the project to collaborate and perform actual renovations tests (§4.11). It finishes with detailed appendixes notably describing the differences between initial KROQI platform and BIM-SPEED platform features and the list of BIM-SPEED services integrated during the project.

2.   Background: the KROQI platform

As a response to a demand from the French public authorities to provide stakeholders, especially small entities (SMEs, VSEs) with tools allowing them to participate in the digital transition of the construction sector, CSTB has started the development of an easy-to-use collaborative web platform open to everybody in 2017. This development was supported under the French Digital Transition Plan for the Building Sector (called PTNB[1]), in consultation with professional organisations and construction stakeholders.

The project was structured around several key stages:

- June 2016: launch of the public digital collaborative platform project
- March 2017: start of the experimentation of the tool
- November 2017:
  - *Launch of the large-scale experimentation phase, in public beta version (at the BATIMAT exhibition in Paris)*
  - *1st Call for Expression of Interest aimed at developing high value-added technical solutions and services for VSEs/SMEs*
- March 2018: launch of the Digital Building Platform, named KROQI, operational and enhanced with interconnected third-party services, identified as part of the Call for Expression of Interest.

The functional foundation of KROQI, accessible free of charge to all stakeholders, provides document management functionalities, collaborative services, and a set of core services like a BIM model checker (see figure 2 below). This base is associated with an ecosystem of complementary and interconnected business services, which were be enriched over time. The platform, with its integrated services, allows all the actors concerned with a building project to manage and share the technical documentation, collaborate around BIM models, set up validation processes, check BIM models, and use innovative tools such as the production of digital models from scanned 2D drawings. Core services and third-party services are accessible through a web platform using SaaS-technology and ensuring data security to an unlimited number of users.

The collaborative suite of the KROQI platform relies on a commercial tool (WIMI), which is hosted on servers rented by the provider[2] of this solution. More technical details on the KROQI platform will be given in the next sections.

At the end of 2018, the platform had around 15,000 registered users (VSE/SMEs, craftsmen, architects, design offices, planners, etc.), including about 4,500 active users. Approximately 4,900 workspaces had been created, of which 800 were used frequently.

100.000+ users had created an account in KROQI in 2021.

---

[1] Plan Transition Numérique dans le Bâtiment
[2] Cloud Solutions SAS
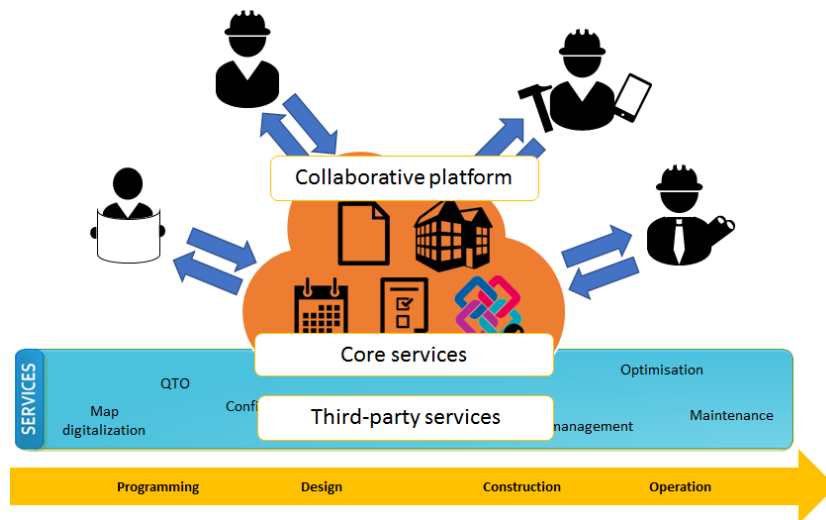
Figure 3.   Functional principles of the KROQI platform

3. Overview of the final BIM-SPEED platform

3.1 Core platform architecture

The figure below shows the architecture of the BIM-SPEED collaborative cloud platform, based on KROQI **that integrates different BIM-SPEED services**. In the context of the French launch of the platform, the first required service to be integrated was a collaboration suite service that could be extended with business services. Here is a more detailed vision of the platform architecture for KROQI-based BIM-SPEED platform:
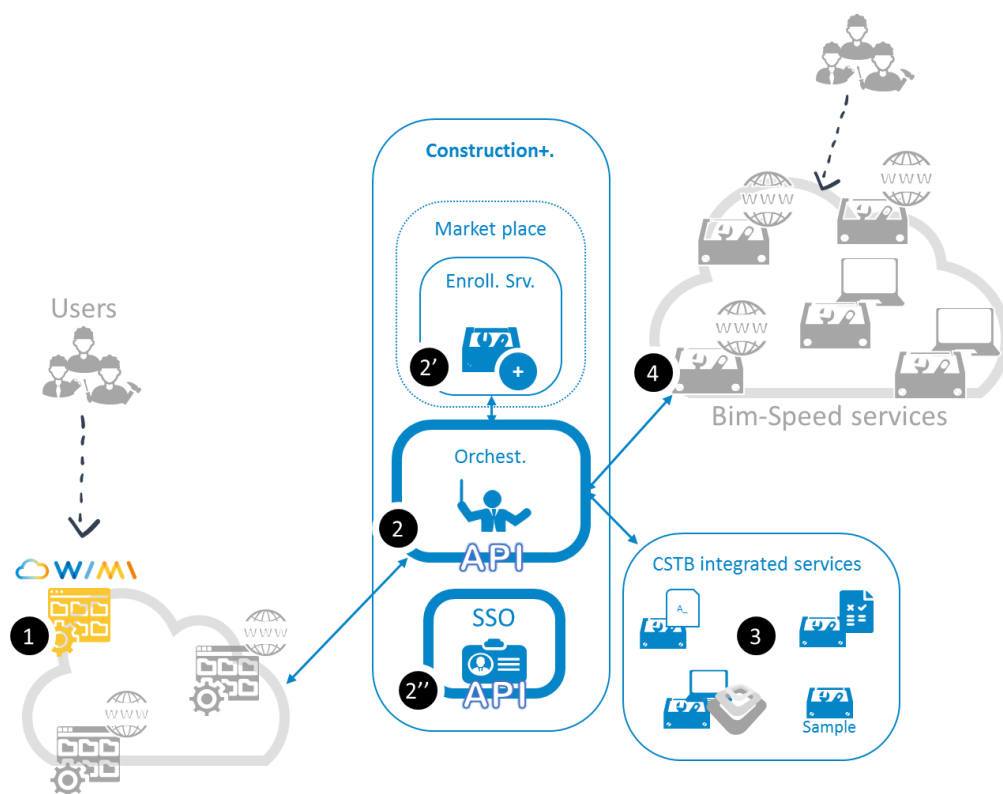
Figure 4.   Detailed vision of the BIM-SPEED platform architecture

The first service integrated within KROQI was the collaboration suite ❶ from Cloud Solutions named WIMI[3]. This collaboration suite enables the exchange of files, and it offers different tools to end-users to communicate.

At the centre of the platform is Construction+, containing the orchestrator ❷ which makes it possible for different services to communicate together and be integrated. This central system has an enrolment service (store) ❷' used by platform administrators to enrol external services (at the right side of the figure). External services use web services over https to be integrated with the platform via APIs. The main role of the platform is to expose abstract APIs to interconnect services and make them appear in the user

---

[3] https://www.wimi-teamwork.com/

interface of the collaboration suite. For instance, the platform provides, via a dedicated API, generic access to user-managed documents in the collaboration suite. Thus, integrated services can use this document management API to interact with users' documents. A Single Sign-on (SSO **2″**) system is integrated into the KROQI platform and used by the BIM-SPEED consortium. Any integrated services will be able to use this SSO central authentication system to identify users and share information about them. CSTB provides KROQI services **3** in the context of the BIM-SPEED platform. These services are: a file naming service, a BIM checking service (improved during BIM-SPEED project), a model viewer application (eveBIM), and a sample service for BIM-SPEED developers to allow them to experiment the use of the central platform API (translated in English).

Finally, BIM-SPEED partners' services **4** were integrated via the Construction+ platform. During the BIM-SPEED project, CSTB has also created extra services dedicated to the project like the Weather Service, the GIS service, or the material service. Services are registered via the enrolment system and then appear in the BIM-SPEED user interface of the integrated collaboration suite. A RESTful API (see appendix 1) is available to services developers to integrate their services into the BIM_SPEED platform. A video[4], targeted to BIM-SPEED developers, describes the process of integrating third-party services into the KROQI platform. It aims to better understand how the service integration process can take place in BIM-SPEED. All technical documentation is available at: https://BIM-SPEED.kroqi.fr/#/integration-sandbox/documents/?directory=58856847.

---

[4] Available at https://www.useloom.com/share/0ee360b1a05f42f7a8cdce54bcb0c50e'

The overall service-integration process is here.
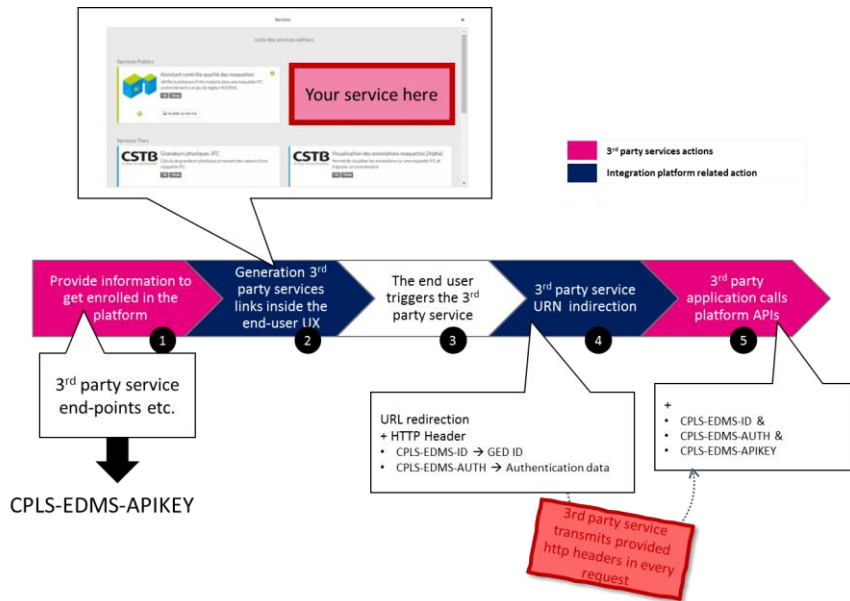
Figure 5.   Service enrolment process

Figure below, composed from several screenshots, shows how an integrated service can be triggered on a folder or on a file of a collaboration suite.
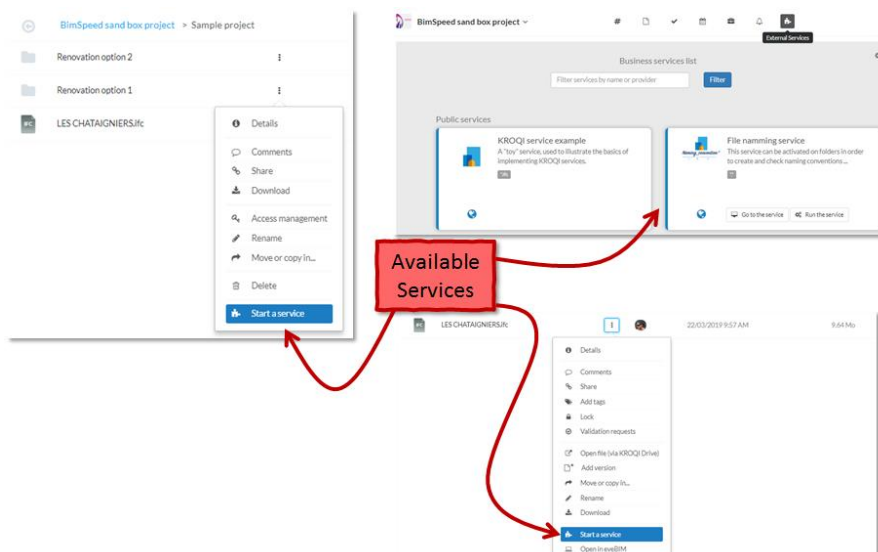
Figure 6.   Third party services integration options in the EDMS

The Construction+ platform uses an architecture based on micro-services, with highly decoupled components. Although this architecture does not impose any specific technology or language on the implementation of services, the underlying components (core model, orchestration, base services...) are written in Python. Data-centric ones use the Django framework to take advantage of its ORM and thus

remain decoupled from the database technology. This is the case, among others, of the central registry that manages service descriptors and associated data for ACL and profile management, index filtering, etc.

Other components use lighter web server frameworks, such as Falcon for instance. This is the case of the EDMS, which abstracts the collaborative suite from the point of view of external services and provides a fully stateless REST API.

All the micro-services are packaged and deployed as Docker containers, their orchestration relying on Kubernetes. This provides valuable features such as automatic scaling, service health management, and self-healing, hot upgrade of component images, etc. To date, the platform is deployed on Google Cloud Platform and is physically hosted on data centres in Western Europe.

Regarding the core collaboration suite, production level features have been set-up with:

- **Resilient infrastructure**

Data storage of the document management and collaboration suite is distributed on two data centers located in France (Roubaix and Strasbourg) managed by the hosting provider Online by Scaleway[5]. A RAID 10 architecture, combining redundancy and data distribution, ensures optimal resilience of this infrastructure and prevents data corruption. Without disturbing the user, defective disks are replaced immediately. Depending on their nature, in real time, every 3 hours or daily, the data is replicated to the second data center.

As for the Construction + middleware, it is hosted on Google Cloud servers in Western Europe, and benefits from the security procedures provided by this host.

- **Maximum accessibility**

Aiming to offer its users maximum accessibility, KROQI/BIM-SPEED's document management and collaboration suite offers the flexibility of cloud computing. In case of a major incident on the primary server, connections are switched to the secondary server to ensure data accessibility without any interruption.

Construction+ is based on a micro-services architecture. All its components are deployed as Docker containers which are hosted on Google Cloud platform (geographical sites in Western Europe). Thanks to Kubernetes orchestrator, load balancing and resilience are guaranteed by replicating the micro-service instances over the 3 nodes of the physical cluster.

- **Privacy**

To ensure privacy and integrity of exchanges and data within the workspaces, KROQI uses digital certificates based on SSL (Secure Socket Layer) technology. These certificates make it possible to encrypt

---

[5] See: https://www.online.net/en

data during exchanges (encrypted connection in AES on 256 bits). The distribution of resources on several servers has no impact on the security of exchanges.

3.2 Final BIM-SPEED integrated platform

The KROQI platform has evolved during the project to meet the BIM-SPEED use cases requirements. The following schema depicts the role of the BIM-SPEED platform and the constellation of technically integrated services at M48.
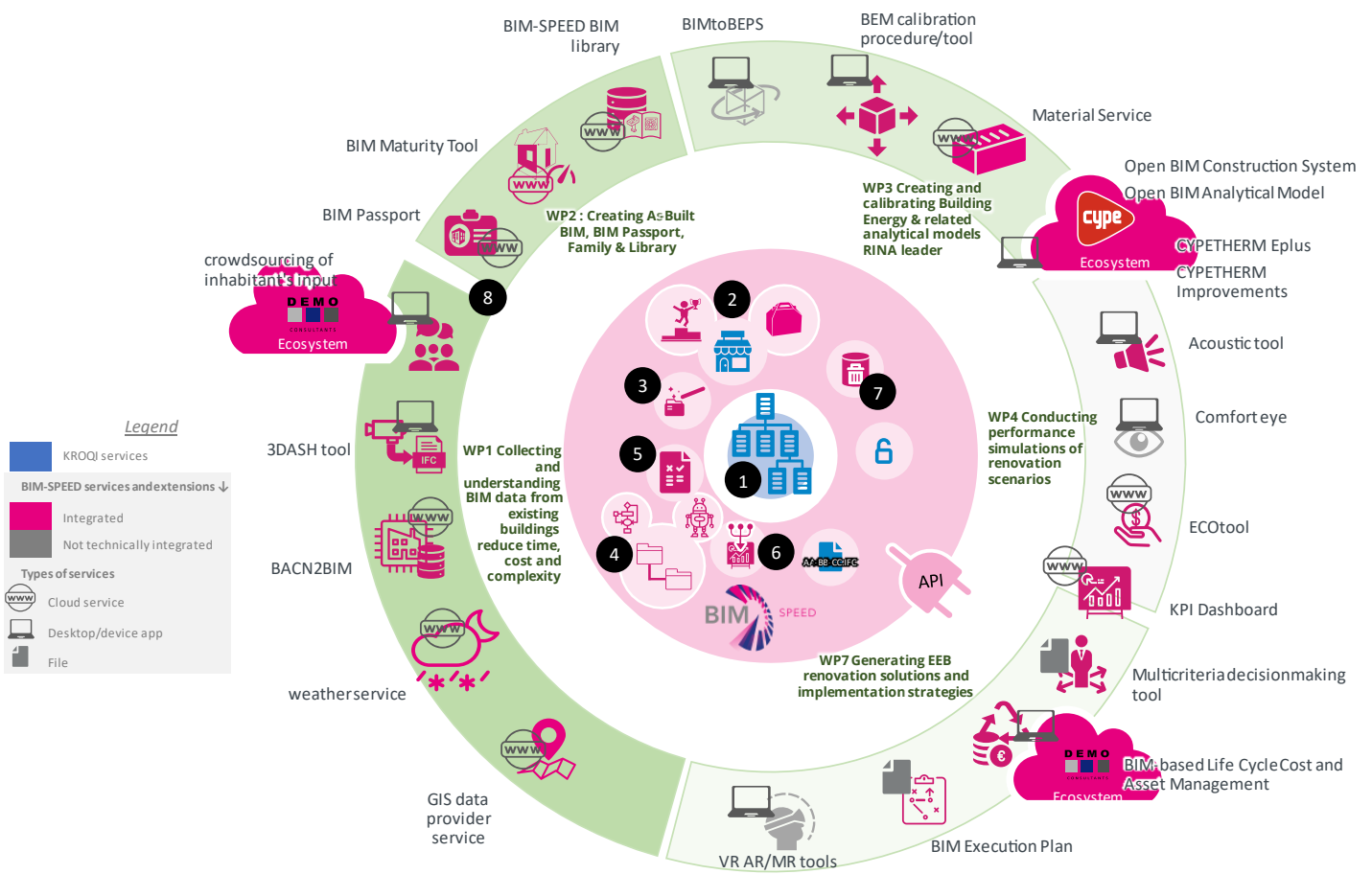
Figure 7.   BIM-SPEED platform at M48

First, the core platform itself has been extended to bring new features required by the project:

1. Collaboration suite services have been used by BIM-SPEED users (see features in APPENDIX 2 – BIM-SPEED platform Teamwork functionalities)

2. The BIM-Speed platform's intention is to provide a flexibility to the renovation market in Europe that requires a high diversity that will support the specific requirements of renovation projects characterized by a wide variety of needs and practices across EU member states and

European districts. To support this end, the platform ensures a flexible integration of a variety of apps through an open app store. The initial KROQI store features have been extended to support the packaging of services (see section 4.2) necessary to expose service packs for renovation. A competition service (see features in section 4.6) has been added to manage the BIM-SPEED competition users' enrollments.

3. A configuration service has been created so users can implement predefined configured renovation projects structures when they start a project (see section 4.3).

4. An extended agent workflow system has been created so that internal services (named agents, ex: the automatic checking system) can be configured and triggered as soon as resources (files) get dropped in automated folders (see section 4.4).

5. The checking system has been updated to use linked data technologies, be automated in the BIM-SPEED workflow system, and configured with specific checking rules defined by the BIM-SPEED project in D7.3 (see section 4.8).

6. A KPI management agent has been created and integrated in the BIM-SPEED folder workflow to process individual KPI data that are individually posted by BIM-SPEED services in platform automated folders, aggregate them into a dashboard data model to be displayed by Metabuild bash-boarding service (see section 4.5).

7. A centralized user data management service has been implemented to unable the users to easily remove any personal data that were exported to external services integrated in the platform (see section 4.9)

Finally, the platform demonstrates the integration of many different applications developed within the BIM-Speed project (step 8 of the schema). These services were created in the different BIM-SPEED work packages that are tackling issues from different steps of the renovation process from initial data acquisition to renovation implementation strategies choices. The technical integration of services demonstrates that the platform allows to seamless integration with other existing BIM platforms such as the BIM-server (provided via project partner CYPE) or the facility management suite (provided by project partner Demo). A set of inter-operable BIM tools, existing and new solutions, all connected through the BIM cloud platform enable Several BIM services to be integrated in the platform, for examples at different steps of the renovation process:

- a GIS data provider that allows access to available Open Data repositories for a specific location that are required to support decision making around renovation projects,
- a weather service to gather weather data for a specific location that is required for estimating the energy need for a specific building and its renovation actions,
- the BACN2BIM tool that links the BIM-Speed platform to an IoT platform to collect data from IoT devices which supports the BACN standard and link it to BIM-models in IFC format,

- the CARTIF 3DDash tool to extract building services from point clouds collected by laser scanning efforts of a building,
- the CSTB IFC Material Enricher Service for importing the required material information for an accurate energy simulation,
- a crowd-sourcing app to understand occupancy behaviour of inhabitants of a building made available through the connection of the BIM-Speed platform with the RE-Suite (provided by project partner Demo),
- an automated energy zoning application made available through the connection of the BIM-Speed platform of project partner CYPE etc.

A full list of the integrated BIM-SPEED services is provided in the §4.11 .

The platform also demonstrates its flexibly to be integrated with other existing BIM platforms and external ecosystems. The integration of BIM-server of project partner CYPE and the facility management suite of project partner Demo demonstrate that versatility of a partner application bridging BIM-SPEED platform with an entire ecosystem.

3.3   Platform production management during the project

Initially when the BIM-SPEED project was proposed, it was planned to clone the KROQI platform on a development environment to create the BIM-SPEED platform at a lower TRL.

With the goal of being closer to an exploitable result in a shorter term, CSTB decided to iteratively embed the BIM-SPEED R&D technical evolutions in the KROQI development cycles to deploy them on the production infrastructures.

The objective of providing innovative services (with possible lower TRL) deployed on a production platform was a technical challenge which required efforts to align KROQI & BIM-SPEED core features roadmaps.

For instance risks of mixing research and development code and production code without compromising security or performances of the production platform had to be managed.

This process enabled the core BIM-SPEED assets to be closer to production quality constraints and more ready for exploitation.

4. BIM-SPEED platform features and services

This paragraph describes some core platform features and services created or updated during BIM-SPEED project.

The **Appendix 3** summarizes the differences between the KROQI platform and the BIM-SPEED platform.

4.1 Localization

Since the platform was developed in a purely French context, there was no English version available at the beginning of the BIM-SPEED project. The localization work in English consisted of:

- Translating the user interface of the collaborative suite
- Translating the user interface of the KROQI Drive (see this module in appendix 3)
- Internationalizing the user interface of the Construction+ platform
- Extending its data model layer with provision for handling multi-lingual data (e.g. displayed name and description of registered services)
- Addressing writing conventions (like date and time format)
- By accessing the KROQI web application for the first time from your computer, the interface language is automatically chosen and corresponds to the language of the web browser installed on the machine. If desired, the user can nevertheless change the language of the interface

4.2   Services Profiling and Bundling

A new feature was added to personalize the KROQI workspace dedicated to projects created in BIM-SPEED. Indeed, a set of third-party services, which have been integrated for use by French stakeholders, does not need to be visible in the context of the BIM-SPEED project. Therefore, a profiling functionality has been developed that allows KROQI administrators to specify the services that can be used in each workspace.

Thus, BIM-SPEED users did only have access to the services integrated into the platform during the BIM-SPEED project, without being polluted by the other services that did remain available in French.

Profile management offers fine-grained settings, profiles can be assigned to workspaces, projects within workspaces, individual users or individual users in a given project.

Admin Service package configuration tool

Renovation service bundles seen by the users on the platform
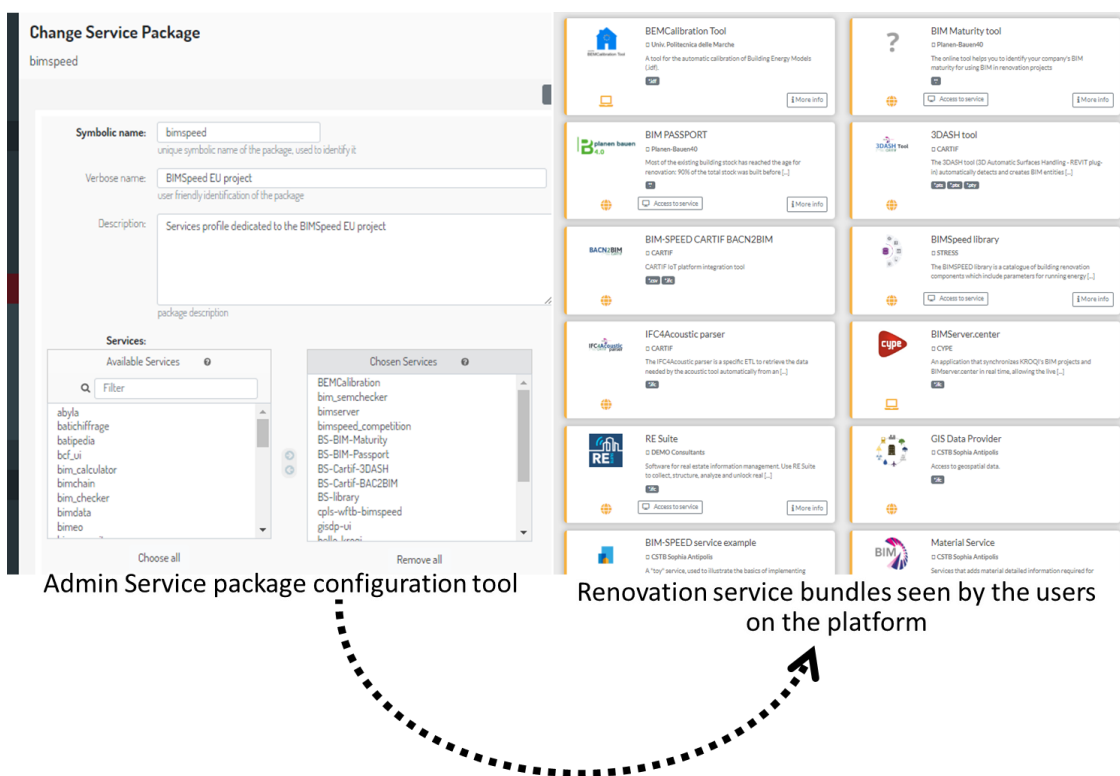
Figure 8.   Services bundles management in BIM-SPEED

4.3   Project structure management service

With this service, BIM-SPEED administrators can create folders structures that BIM-SPEED users were able to implement in their project via a dedicated "Folder structure & automation service".
Administrators can create folder structures adapted to various renovation processes.
For instance, a P2ENDURE[6]-inspired folder structure has been created to support BIM-SPEED renovation processes. This structure contains default resources created during the project like the "Multicriteria decision making tool" which is an excel file, the BIM Execution Plan which is a word file and links to external services like the build competition resources.
Such templates can be automated via the workflow system which is described in the next section.
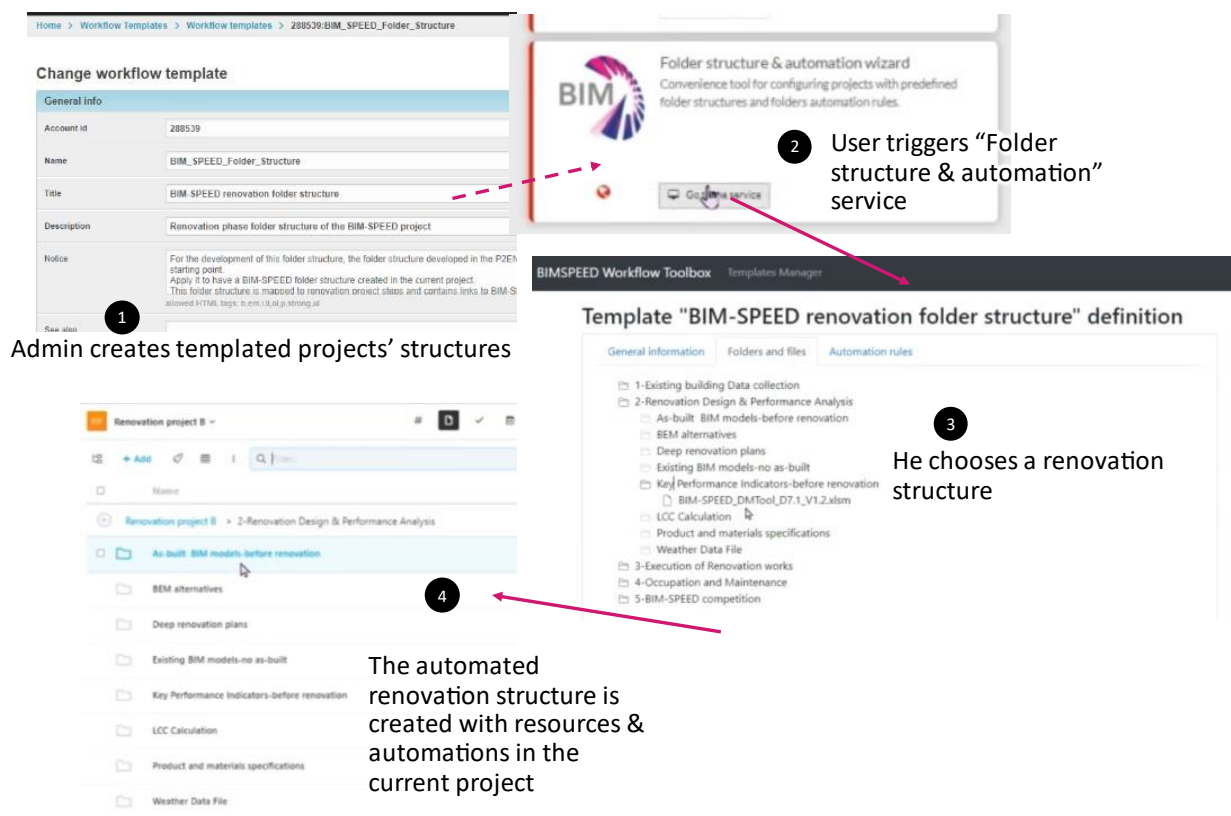
Figure 9.   BIM-SPEED structure management services (admi & user)

4.4   BIM-SPEED workflows system

The BIM-SPEED Workflows propose predefined folder organisations, also known as "templates" (see 1 in the figure), that the BIM-SPEED users can implement in the Collaboration suite. Folders come along with services automations based on Collaboration suite files events (see 2 in the figure). BIM-SPEED users can
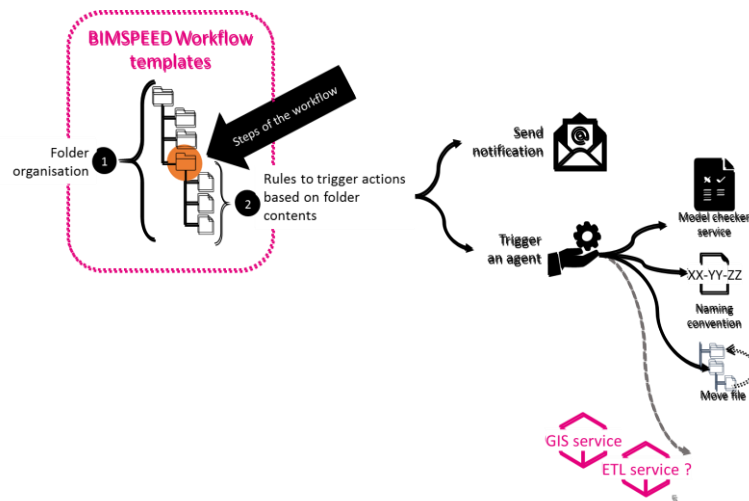
Figure 10.   BIM-SPEED workflows system concepts

experience steps of a renovation workflow as a set of folders to work in.

The process can be automated so that when a file is dropped into it, some internal or external services are triggered. Triggered services may be any types of BIM-SPEED platform internal services (like notification services, file moving service, checker service) or any cloud BIM-SPEED partner services.

The actors of this service are :

BIM-SPEED workflow designers (BIM-SPEED team) who design BIM-SPEED workflows, based on renovation use cases and BIM-SPEED partner

tools provided in BIM-SPEED (ex: trigger IFC file checking on file upload event in a folder).

BIM-SPEED project administrators can then **install predefined workflow** templates in their BIM-SPEED platform created projects. **BIM-SPEED project users** can **use** the predefined folder structures to store content and automatically trigger services on these folders contents.
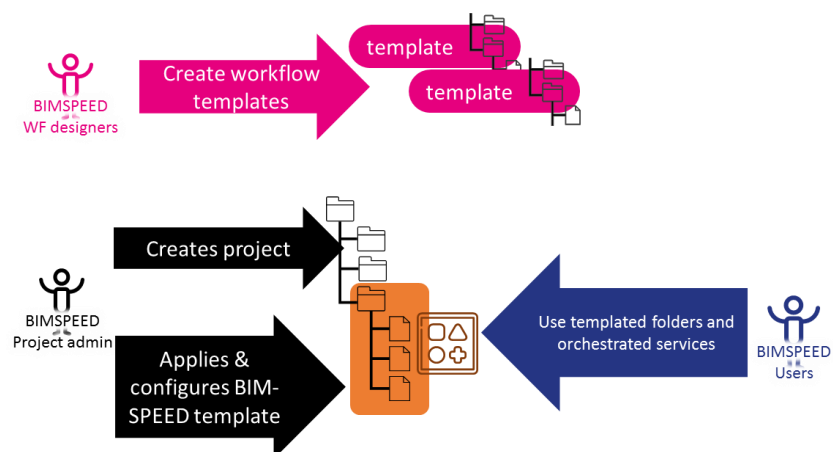
Figure 11.   BIM-SPEED workflows system actor

Here is a concrete example to handle a CYPETHERM simulation scenario:

A BIM-SPEED workflow template creates a folder structure that is representing a renovation simulation process. In the first folder, at step one, an operator works on preparing the IFC file which will be the base for CYPETHERM[7] simulation. To that extend, he is working in the "work in progress" (WIP see 1 in the figure) folder. When the operator is done with preparing
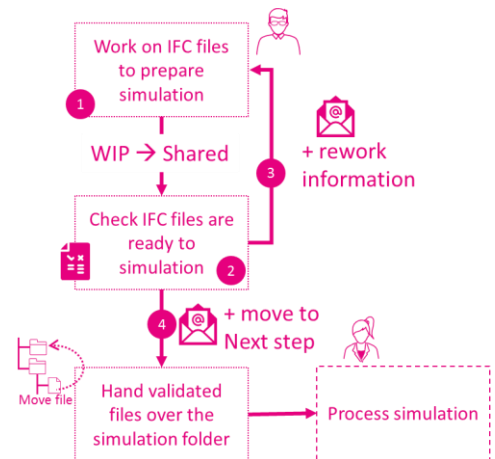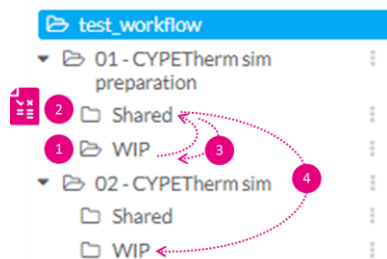
Figure 12.   Sample workflow for model checking

the IFC file which is the input of the simulation, he drops the file in the "shared" folder (see 2 in the figure). At that step, the model checker checks if the IFC file contains the relevant information to perform a CYPETHERM simulation (NB: The IFC model Checker has been provided with a set of rules targeted to BIM-SPEED simulation requirements). If the IFC file fails the checking process, the Notification Service is triggered to notify the operator that the prepared IFC file is missing important information: detailed failed-checking reports (PDF & BCFZIP files) are put in the work in progress folder, along with the IFC file which is moved back from shared folder as well (see 3 in the figure).

Later, if the shared IFC file is checked to be compliant with simulation requirements, a notification is sent to the person responsible for the simulation so that he/she knows that he/she can perform the simulation task with a well calibrated file (see 4 in the figure). The validated IFC is then moved from the preparation/shared folder to the simulation/work in progress folder so that the simulation operator can use it in that dedicated folder.

A video showing the application of BIM-SPEED renovation rules automatic verification can be found here : https://bimspeed.kroqi.fr/shared/#/file/a647aceee6897cb573179dc875361b986d88d1606d0bec564759821 62163c2dc

---

[7] https://info.cype.com/en/software/cypetherm-eplus/

4.5   BIM-SPEED KPI integration service

In the context of BIM-SPEED, dashboards are presented to the end users to help them in their renovation decisions. Dashboards present "aggregated KPI" data leveraging "services KPI data" that are produced by BIM-SPEED services. This section describes the technical workflow created to manage KPIs inside the BIM-SPEED platform.

The schema below depicts the technical flow of the BIM-SPEED platform dashboarding process:

In the context of BIM-SPEED there are several actors to be considered in the process flow of generating renovation dashboards. In this BPMN diagram the actors are represented by different swim lanes:

- The **User** is the final user of the integrated solution: the AEC stakeholder using BIM-SPEED ecosystem

- the **BIM-SPEED service provider** this one of the BIM-SPEED partners providing a technical service or tool for renovation at a specific step of the renovation project

- **Metabuild platform** represents the Metabuild backend containing the BIM-SPEED dashboard service

- Finally, the **BIM-SPEED platform** is the place where documents are managed, and BIM-SPEED services can be registered and triggered by BIM-SPEED users.
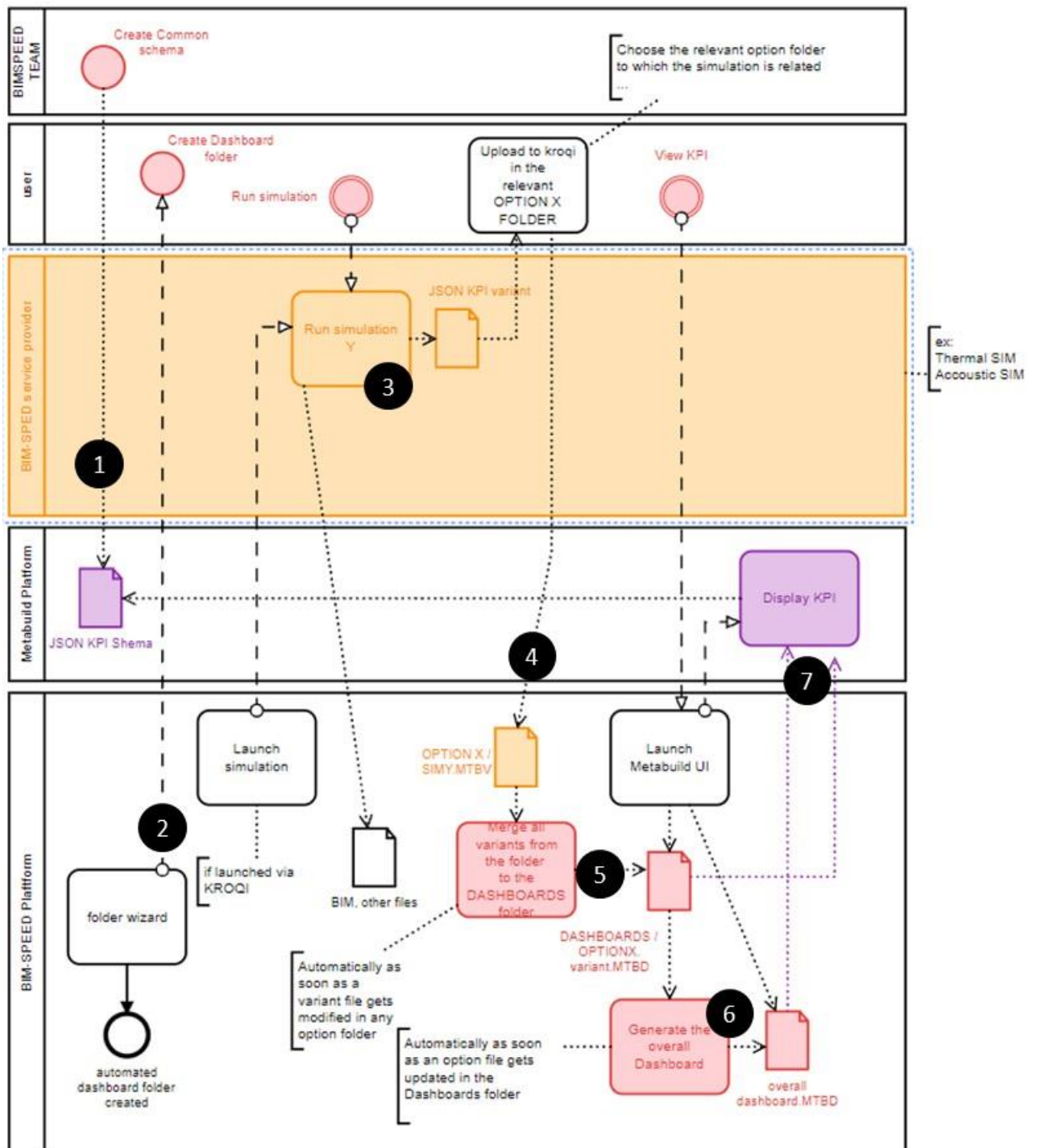
Figure 13.   BIM-SPEED KPI integration service process

The following points are referencing the numbered black points in the BPMN schema.

Orange colour mostly refers to BIM-SPEED integrated-services data and processes, purple colour refers to Metabuild data and processes, while red colour mostly represents data and processes that are managed by the BIM-SPEED platform.

1. The BIM-SPEED experts **define the dashboards technical schemas** inside the Metabuild platform
2. using the BIM-SPEED platform folder wizard service, the project's users can **create an automated Renovation option folder** that was used to put any formatted simulations variances according to the schema defined at step 1
3. Later, a user is using one simulation tool from BIM-SPEED consortium to prepare a renovation option. This simulation tool needs to generate a **variant file for the renovation option**, which is compliant with the schema which was defined as step 1.
4. the simulation responsible person then needs to **upload the result variant file of the simulation under the relevant renovation option folder** inside the BIM-SPEED Renovation option folder.
5. The dashboard folder is automated by nature, as soon as the variant file gets dropped or updated in a Renovation option folder, the process gets triggered which **concatenates all the options variants from the** Renovation option folder **into an option-dashboard file which is put in the Dashboards folder**
6. there is another automation taking place at this step: anytime an aggregated dashboard from a Renovation option folder gets dropped inside **Dashboard's folder** the process aggregates all the option dashboard files into overall integrated dashboard file.
7. later, browsing the **Dashboards folder**, the user can trigger the Metabuild dashboard service on any option dashboard or overall dashboard file (.MTBD) that can be found inside the dashboard folder to do view results via the Metabuild service.

(Colours in the text above are referencing the folder colours in the following schema)

Dashboard folders structures

Here is folders structure for the BIM-SPEED dashboards.
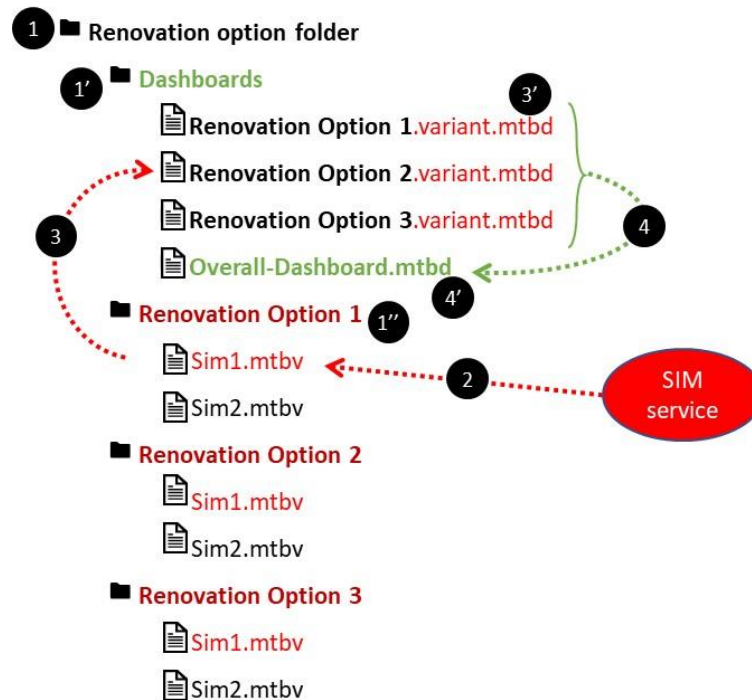
1. The BIM-SPEED folder wizard service made it possible for users to create a Renovation option folder. This automated folder contains a **Dashboards folder** (see 1') which did receive all the aggregated dashboard files from various renovation options scenarios. It can contain as many renovation option folders (see 1'') as required by the project team requiring to simulate various renovation options. The wizard may create some sample renovation folder, but the project's users can manually create as many "renovation option" folders as they want under the Renovation option folder.

2. During the renovation design process, a simulation service could be run that generates, for the purpose of various options evaluations, simulation results in the format of the predefined Metabuild[8] dashboarding schema. The renovation responsible person must drop the simulations result file (variant file) the relevant Renovation option folder.

3. As soon as a file gets dropped inside a Renovation option folder, all variant files contained by this folder are computed to be aggregated into a renovation option file which is put in the

---

[8] https://www.metabuild.io/en/

Dashboards folder. The convention is that this dashboard file takes a name of the form: ***<<name of the option folder>>.variant.mtbd*** (see 3').

4. as soon as the **Dashboards folder** gets updated we with a renovation option file containing the "*variant.mtbd*" pattern in its name, all the renovation-option-dashboard files get compiled and aggregated into an **Overall-Dashboard.mtbd** which is set in the **Dashboards folder** (see 4').

4.6   BIM-SPEED competition service
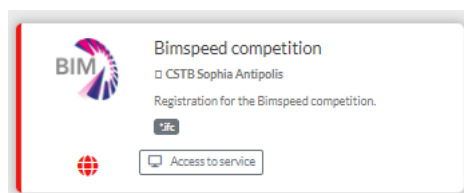
Figure 15.   BIM-SPEED competition service icon in the service store

The "EU BIM for Building Renovation Competition"[9] aims at getting teams together with different backgrounds who are active in the design and construction industry using the BIM-SPEED platform and tools to perform renovation projects.

To register these teams, a competition enrollment service has been created and added to the platform to help the competition management by leveraging BIM-SPEED platform core features.

The folowing BPMN diagram presents the BIM-SPEED competition implemented service workflow at M48 that supported the competition action:

---

[9] https://www.bim-speed.eu/en/competition
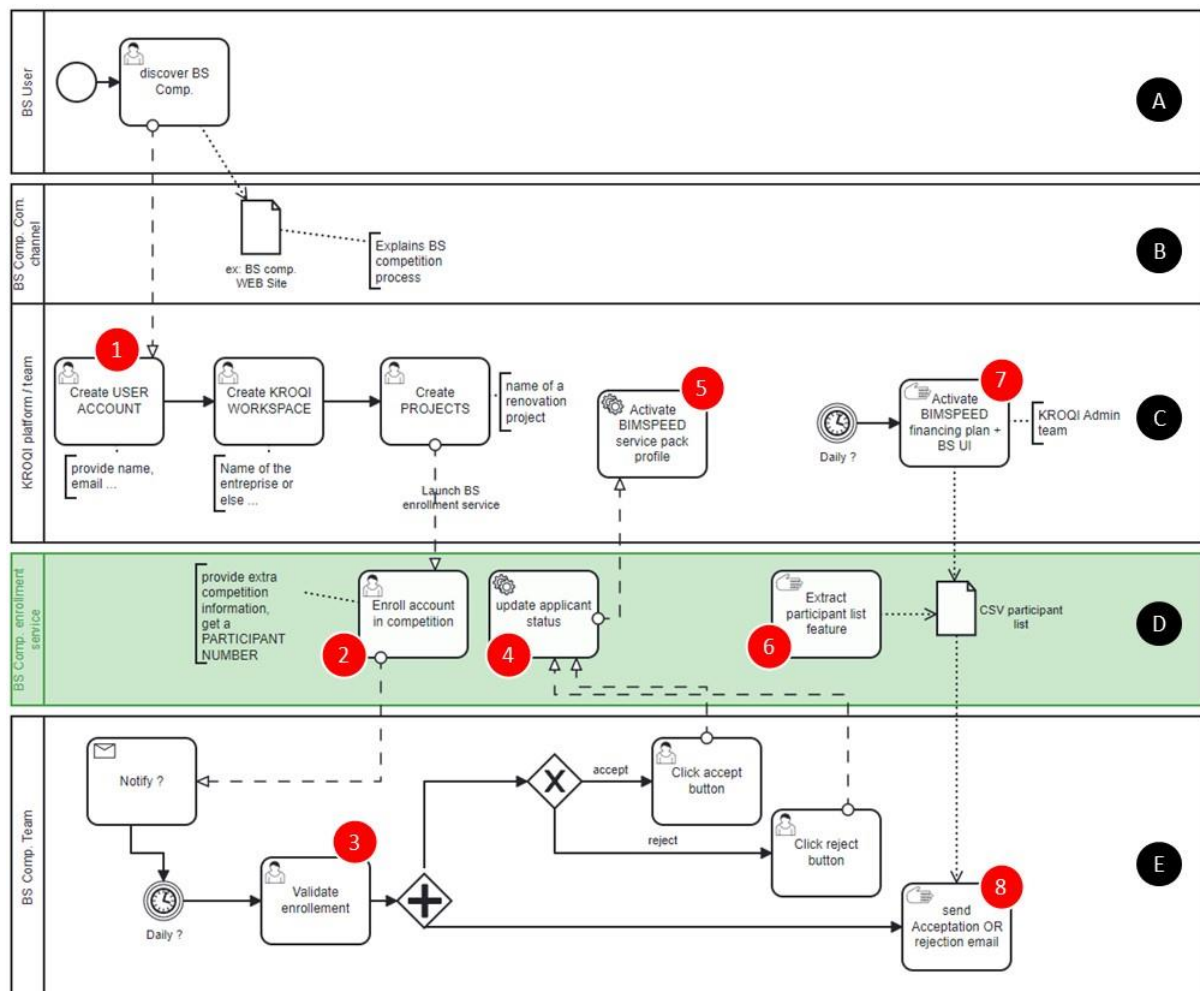
Figure 16.   BIM-SPEED competition service BPMN workflow

Several actors are involved in the competition service use case:

- A- the end-user of the solution (renovation stakeholders)
- B- the BIM-SPEED platform in its "file-sharing" features. Thanks Project structure management service (see §4.3), competition documents can be automatically instantiated in the BIM-SPEED file structure for users to find them
- C- the platform in its "users and services" management dimension
- D- the competition management service which has been added to the BIM-SPEED platform
- E- the competition management team which is using the competition management service to administer the competition and validate users wanting to take part in it

Here are the main steps of the competition enrolment workflow:

1. a user wants to take parts in the competition, he first starts by creating a KROQI user account then a workspace and a project

2. from a created KROQI project, the user triggers the BIM-SPEED competition enrolment service. The user then fills a form in, presenting information about his profile and his motivations to take part in the competition

3. the competition management team uses an administrative interface to validate competitors' profiles (accept them or reject them)

4. the competition service traces the status of user's enrolment in the competition

5. in the case where a user is accepted, the BIM-SPEED service profile is automatically activated for him, turning his regular KROQI account into a BIM-SPEED account presenting BIM-SPEED services pack.

6. an extraction can be made to see the current list of the users enrolled in the competition

7. this list is used to activate the free-of-charge version of the KROQI financing plan for BIM-SPEED competition users: they can have as many users, storage and projects as required in their collaboration account.

8. This competition users-list can be used by the competition management board to communicate with competition members

Here is a part of the user enrolment form :

Country of team leader (EU based) :

Bulgaria

Competition Category :

○ Student (1)   ● Entreprise (2)

Company size :

Select ...

Team information :

Team name :

How many team members do you expect to participate ? :

Participants' profiles (multiple options are possible) :

☐ Architects   ☐ Engineers   ☐ Contractors   ☐ Surveyors   ☐ Students

Project description :

Title of the renovation project :

Location of the building (EU based) :

Select ...

Type of buildings :

Select ...

Describe briefly the residential building(s) (500 characters maximum) :

Figure 17.   BIM-SPEED competition service enrolment form partial capture

4.7   Sample third-party service

A sample service has been developed and integrated to illustrate how the platform interacts with third-party services. A sample BIM-SPEED-integrated program has been created to help the consortium partners to understand the philosophy and the APIs to integrate external BIM-SPEED services to the platform. The code is provided in Python and is made available in a developers-dedicated project[10] on the BIM-SPEED platform.

The program can be executed on the BIM-SPEED platform to demonstrate how to process IFC documents.
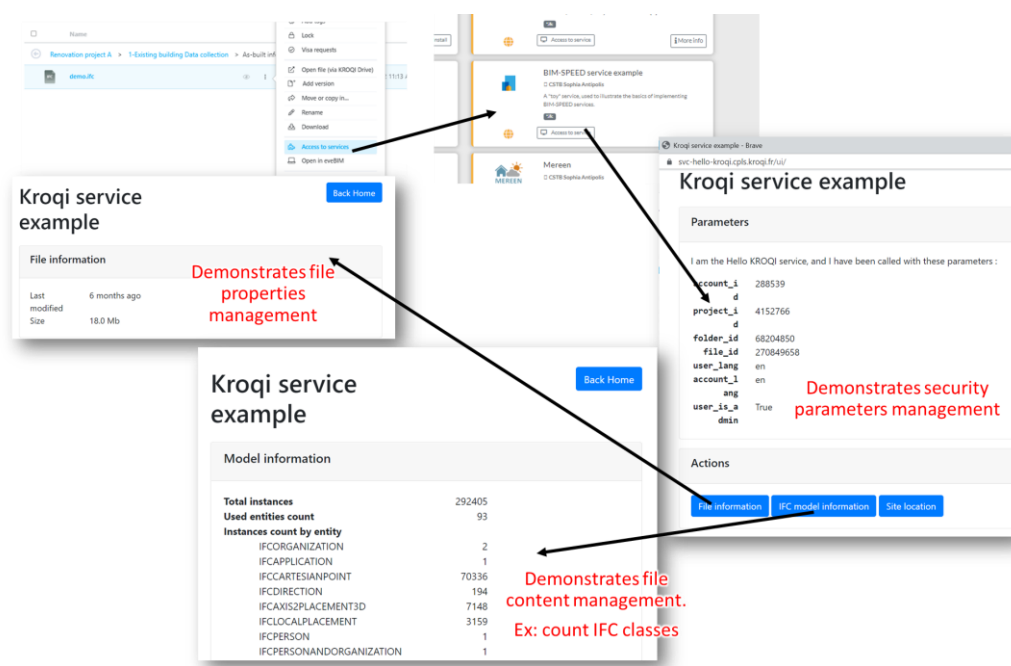
Figure 18.   Sample BIM-SPEED-integrated service execution on the BIM-SPEED platform

The service has been enrolled in the service list under the name 'KROQI service example', and can be started on any IFC file, e.g. the 'LES CHATAIGNIERS.ifc' sample file stored in the Sample project folder of the platform (accessible to any BIM-SPEED user).

---

[10] https://bimspeed.kroqi.fr/shared/#/folder/59bb19a997252eb2256edcedfebd8cae

Pragmatic example of API calls

```python
class FileInfoHandler(ActionHandler):
    """ Concrete handler class for the "File info" button click request
    """
    def handle(self):
        # invoke the EDMS API to obtain the file information
        response = requests.get(
            # build the full URL of the entry point returning information about a file
            url=self.edms_urls_root + f'projects/{self.project_id}/docs/{self.file_id}',
            # include the EDMS related headers which have been prepared by the parent class
            headers=self.edms_headers
        )
        try:
            response.raise_for_status()
```

Figure 19.   Python code demonstrating how to integrate a third-party service

4.8   Semantic BIM checker

The objective of this service is to verify whether a BIM model contains all the information required to be processed by an application or service at a given time in the renovation process. This validation, which is part of the quality control of the digital models uploaded on the platform, can concern the existence of certain properties, property values, or more complex relationships between the values of several properties.

Initially, the main target of the initial technical module was to validate an IFC file against rules expressed in mvdXML[11] format.

However, there were many drawbacks of MvdXML for extracting building views such as lack of logical formalisms, sole consideration of IFC schema, and MVD-based view constructors are not very flexible and dynamic. Verification by MvdXML rules was also very limited. Major limitations were identified such as the restricted scope of applying conditions and constraints on several branches of an IFC model, poor geometric analysis of an IFC model (e.g. adjacency), lack of mathematical calculations, support of only static verification of a model, etc. On the other hand, Semantic Web technologies allow for the semantic verification of IFC models to enable compliance checking of IFC construction models with fast querying performance.

---

[11] https://technical.buildingsmart.org/standards/ifc/mvd/mvdxml/

Therefore, a new approach has been developed during the project that relies on Semantic Web[12] technologies. Roughly speaking, this approach requires converting the IFC file (on the fly) into an RDF[13] Triple Store database, then applying SPARQL[14] queries to these triples to check rules.

CSTB has redesigned the IFC model checker included in the French KROQI platform to integrate semantic features. Its code design and triple store management is improved in the context of BIM-SPEED to be automated with BIM-SPEED workflow system (see section 4.4).

The following schema presents the principle of the BIM-SPEED automation for the internal checker service:
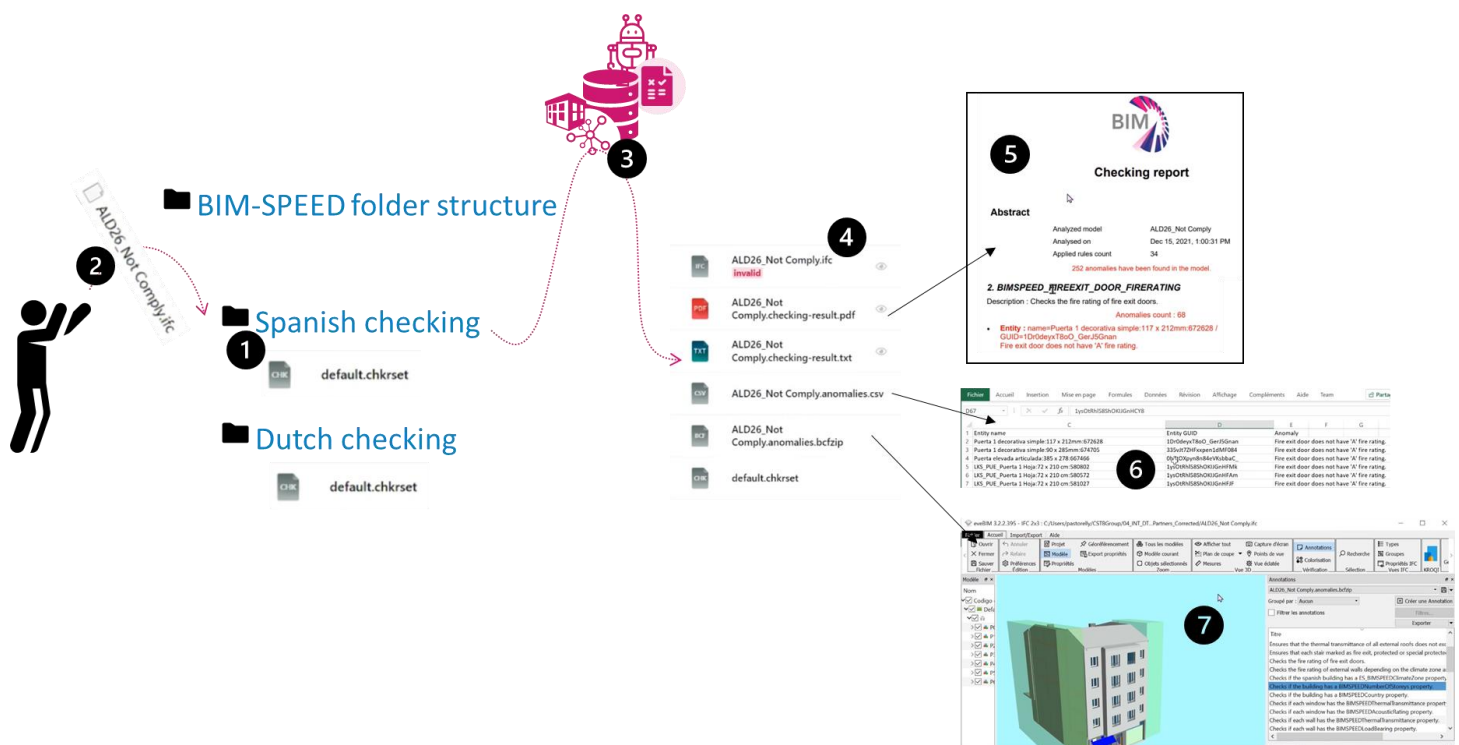
Figure 20.   BIM-SPEED internal checker service workflow example

1. With the BIM-SPEED workflow features, activating the checker on a specific folder is quite simple: as soon as the configuration and verification queries file archive (extension CHKRSET) is present in a folder, anytime and IFC file gets dropped in this folder the checking process does automatically take place

2. The user drops an IFC file in a checking-configured folder

---

[12] https://en.wikipedia.org/wiki/Semantic_Web
[13] https://en.wikipedia.org/wiki/Resource_Description_Framework
[14] https://en.wikipedia.org/wiki/SPARQL

3. Once the folder contains checking rules, the checker agent is automatically triggered in the background taking as an input the just dropped IFC file and the checking BIM-SPEED rules found in the folder (expressed in SPARQL in the CHKRSET archive).

4. The checker generates several types of outputs depending on its configuration. All the outputs are found in the process-initiating folder. The IFC file is marked with the tag expressing whether the file passes the conformity checks expressed in the checking rule set file. In this example, the file is marked as invalid.

5. A human-readable PDF report is generated

6. A CSV file is generated as well that lists the IDs is of IFC objects failing any checking rules

7. BFCZip comments file is also generated that can be used in any open BIM-compatible editor to spot the rule-failing objects as standard BIM Collaboration Format (BCF[15]) comments. This is very useful for architects at delivery time to easily check and correct constraints of a model in their preferred model editor, depending on country rules defined in BIM-SPEED. In this example, we can see the failing rules expressed as BCF comments and displayed in the free eveBIM viewer (see section 4.10) that is provided to BIM-SPEED users.

Specific model checking rules have been implemented in SPARQL, according to the BIM- BIM-SPEED D7.3 specifications:

---

[15] https://en.wikipedia.org/wiki/BIM_Collaboration_Format

Overall technical steps of the checking service are described here:

Figure 21.   Overall technical steps of the checking service

A video showing the application of BIM-SPEED renovation rules automatic verification can be found here : https://bimspeed.kroqi.fr/shared/#/file/a647aceee6897cb573179dc875361b986d88d1606d0bec564759821 62163c2dc

4.9   Centralized user data management service

The BIM-SPEED platform is a "mashup" platform which integrates services from different vendors. Users are using the platform to store and exchange documents. From the platform, they can trigger external integrated services which use BIM-SPEED API to retrieve data from the document management system and process it outside of the BIM-SPEED platform.

So, to create integrated renovation services pipelines, different external services are pulling data out of the BIM-SPEED platform infrastructures to store pulled user data on their infrastructures.

As a result, it may be hard for BIM-SPEED users to identify and trace what data have been exported from their projects to the various BIM-SPEED external services used along the renovation processes.

It is thus relevant in the BIM-SPEED one-stop access platform to create a centralized service which makes it possible for the end-users to "opt-out" and delete from one place data that has been shared with various services from BIM-SPEED vendors for a BIM-SPEED project.

The following schema exposes the data management process implemented by the centralized data deletion service in BIM-SPEED :
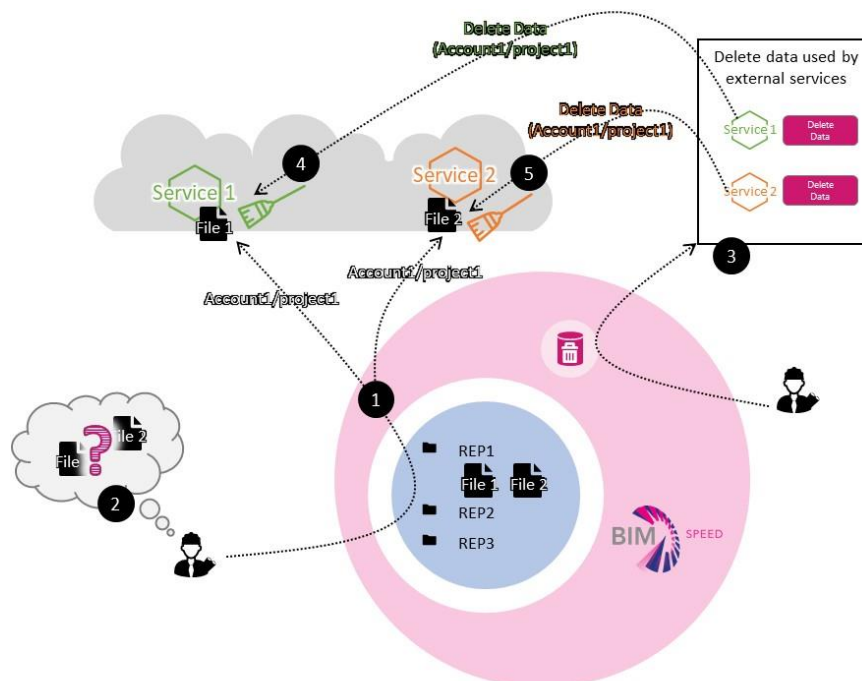
Figure 22.   Data management process for the centralized data deletion service in BIM-SPEED

1. Users trigger BIM-SPEED services from the platform interface. BIM-SPEED services are triggered on specific resources like IFC files for instance. These files are pulled by the external services that are using the platform API. When calling the platform API, an external service receives the account ID and project ID from which resources are pulled. Pulled resources are then duplicated and stored outside of the BIM-SPEED platform scope.

2. After a while, a user may not remember the number of services he has used along the way and what files have been exported from the current account/project to the triggered services.

3. The user can then access the central deletion service where every integrated service is listed.

4. The user can select from that interface one specific integrated service to trigger previously imported data deletion. Technically, **a deletion URL path is requested on the vendors' servers that has been provided by the vendor at registration time**. The BIM-SPEED partner vendor has implemented a **deletion web service method** that receives an account ID and a project ID, and deletes any imported file related to that specific project

5. The user can then select any other service that has implemented the deletion method to be sure that his project's exported data is cleared on any other BIM-SPEED partner's infrastructures.

The implementation of a centralized deletion method can be one angular practice to integrate various services and keep data under the user control in BIM-SPEED platform.

4.10   Preexisting CSTB services

File naming service

The collaboration suite used in KROQI doesn't work as an electronic document system where users drop well-named files when files are final deliverables; it is rather a file synchronization and sharing application like Dropbox or Google Drive that let users freely name their files. It is very permissive for users in terms of file creation and naming, but in some construction projects, managers must share files by naming them in a certain way according to a naming convention. For this purpose, the file naming service has been created, which makes it possible to create and assign a naming convention to a folder. When a user synchronizes files that are misnamed according to the assigned naming convention, a warning is issued via a tag associated with the file. Users can then trigger the file naming service on the misnamed file to open a wizard that helps them rename the file according to the appropriate local naming convention.
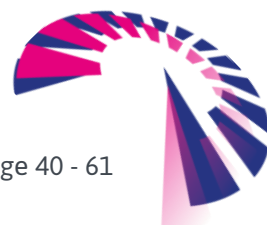
Here is how the file naming service works:
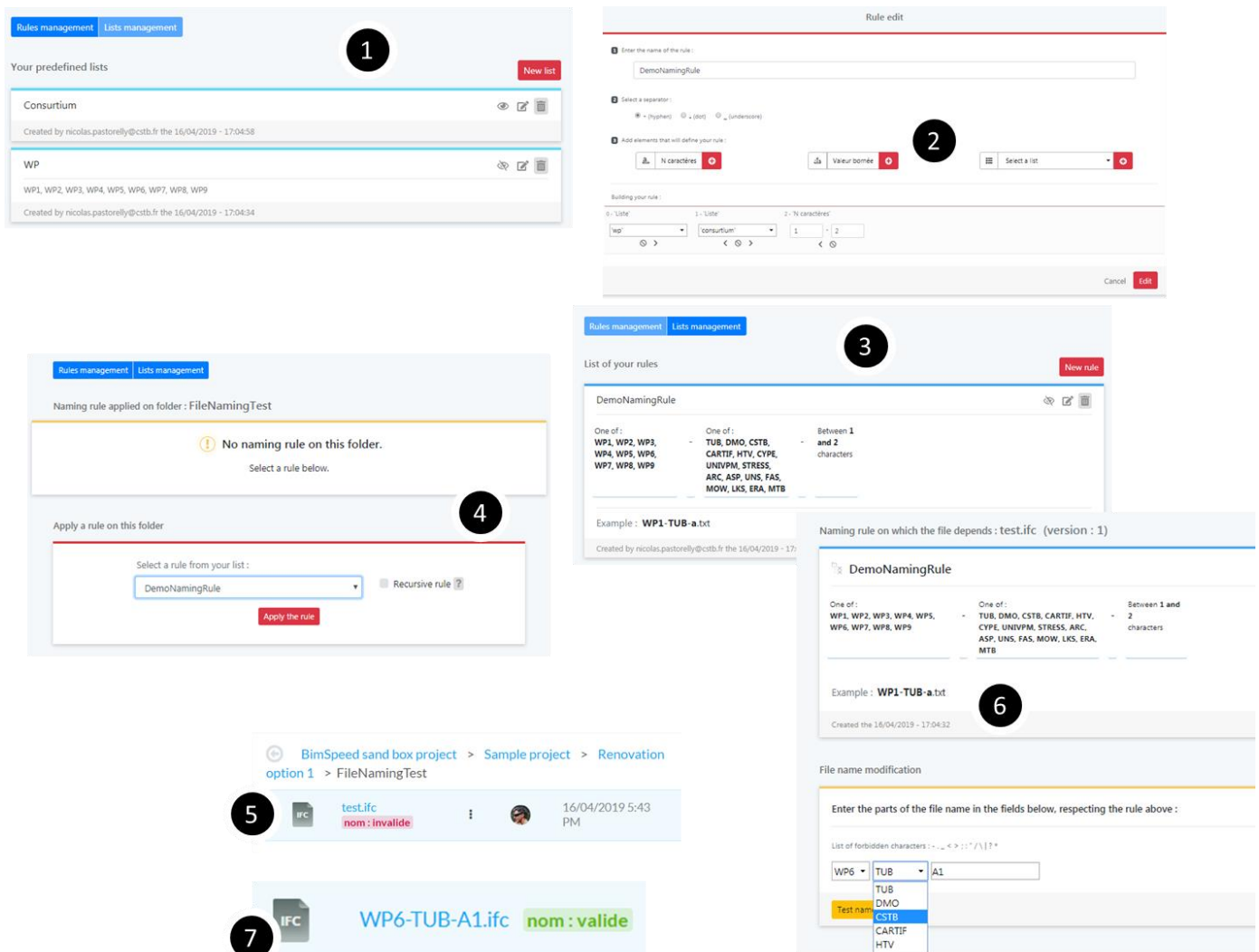
Figure 23.   Process of the file naming service

1. The project manager can create naming conventions. To do this, he/she can define predefined lists of names that will be reused in parts of file names later.

2. A naming convention gets created. A naming convention has a name, specifies the main separator, and has a list of constituent elements that can be: a predefined list of names, a range of alphanumeric characters, or a range of numbers. A naming convention is a set of several of these elements configured by the manager.

3. A new naming convention has been created.

4. By triggering the naming service on a folder, the project manager can assign a naming convention to it.

5. A file gets synchronized in the folder holding the naming convention. It is misnamed and then it is tagged as "invalid".

6. The user triggers the file naming service on the misnamed file. The wizard helps him to find the right name for the file.

7. The user validates the renaming, the file gets properly renamed.

eveBIM

eveBIM is a free openBIM and multi-scale BIM viewer. It allows the integration, in the same environment, of different data sets (BIM IFC, TOPO IGN, CityGML, 3D Photogrammetry, etc.). It provides quality display and rendering, textured BIM, measurements, viewpoints, selection baskets, etc., as well as data and quantitative extraction tools. It also provides collaborative work tools (annotations in BCF2 format). Many plugins are available or to come. In addition, the eveBIM SDK is a software environment to develop plug-ins in eveBIM (e.g. for connecting to applications, services or databases).

eveBIM is a desktop viewer that can be freely downloaded from the KROQI/BIM-SPEED platform by choosing 'Get Apps' in the 'Option' module (left bar of the user interface).
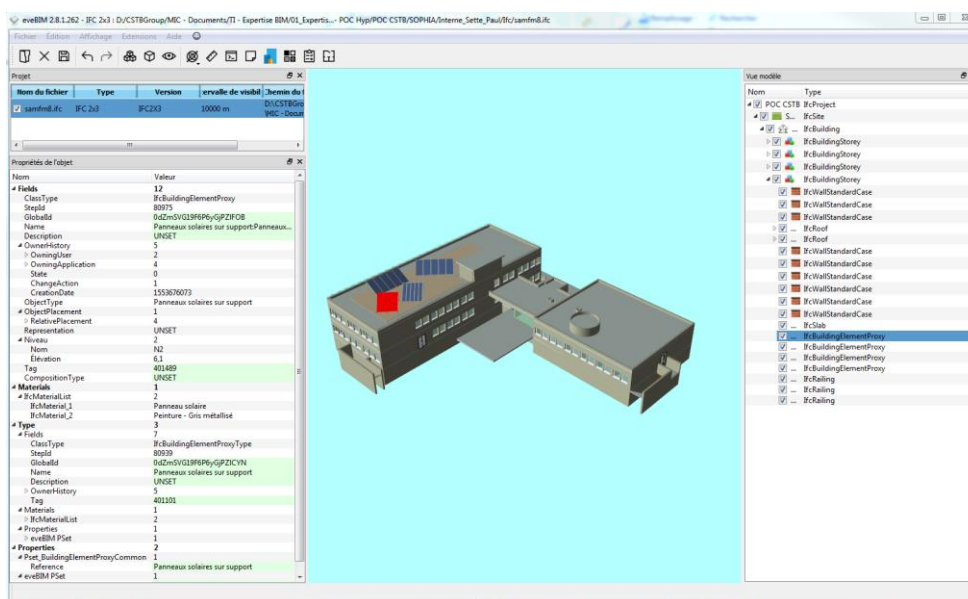
Figure 24.   Navigating within a building with eveBIM
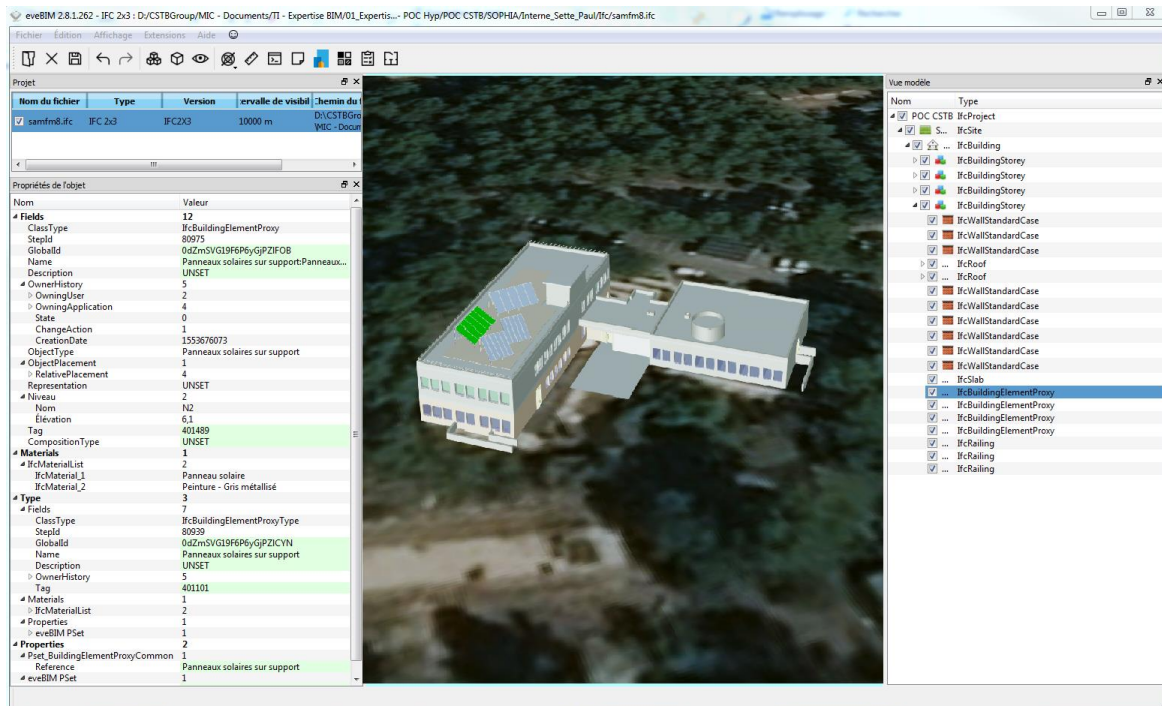
Figure 25. Visualizing a project in its environment with eveBIM

4.11 List of integrated BIM-SPEED services

This section presents the full list of BIM-SPEED services and their integration at the end of the project.

Tool	Description	Stage of use	Developer	Executable from the platform
BIM-based Life Cycle Cost and Asset Management	The purpose of life-cycle costing is to quantify the life-cycle cost (LCC) for input into a decision-making or evaluation process and it includes inputs from other evaluations (e.g. environmental assessment, design assessment, safety assessment, functionality assessment, and regulatory compliance assessment). The quantification should be to the level of detail that is required for key project stages. The scope of costs included/excluded from an LCC analysis should be defined and agreed upon with the client at the outset.	Renovation design	DEMO	Yes, via RE suite
CYPETHERM improvements	CYPETHERM Improvements is a tool for energy audits and analysis of improvement measures in buildings. This application acts as a complement to CYPETHERM energy simulation programs that use the EnergyPlus™ analysis motor. The initial situation of the building and improvement measures can be imported from files in XML format that are generated by CYPETHERM energy simulation.	Performance analysis, Execution of renovation works	CYPE	Yes, via BIMServer.center
Open BIM Analytical Model	Open BIM analytical Model is a tool for automatically creating high-precision energy models (BEM) which are calculated in other specific thermal and acoustic analysis and simulation applications. The tool can be used by Architects, Engineers, and Energy experts who need to perform precise energy analysis and simulations taking into consideration information that is not considered in a BIM model, such as thermal bridges. This tool automates the generation of the advanced analytical model saves considerable time and improves the accuracy of the calculation results and the quality of the whole process. The time reduction will depend on the complexity of the project and the accuracy of the results can easily be justified by comparing two calculation results.	Performance analysis	CYPE	Yes, via BIMServer.center
Open BIM Construction Systems	The Open BIM Construction System is a tool for determining building systems in BIM models to prepare the model for energy simulation and analysis. This tool provides addition and homogenization of relevant information for the energy simulation. A flexible system adapted to different use cases automatically update information based on an Open BIM interconnected workflow.	Performance analysis, Execution of renovation works	CYPE	Yes, via BIMServer.center

Multicriteria Decision making tool	The multicriteria decision-making methodology and tool assist the selection of a suitable renovation alternative considering the inputs of all involved in the decision-making process. In the tool, you can establish the assessment criteria for all proposed alternatives, collect the preferences from all involved in the decision process regarding all criteria proposed. The result is a ranking showing the alternatives according to their performance in relation to the preferences collected. It is a structured approach to engage different stakeholders and conduct the decision-making process, to capture the preferences of different stakeholders' groups, and to transparently identify which renovation alternatives are more suitable according to the objectives and preferences of the different stakeholders. Additionally, it is a sustainable approach considering environmental, social, and economic aspects as well as an intuitive and accessible tool based on an excel file that is easy to understand and to work with.	Execution of renovation works	TUB	Yes, as a file in the project's structure
BIM Execution Plan	BEP is a plan defining the goals of implementing BIM technology in a project. It describes how the constructed model will be applied, explains the implementation processes and the ways of information exchange. It also contains information on the entire project infrastructure required for a successful BIM implementation. This tool offers clear communication, improved collaboration as well as data and project transparency.	Renovation design, Execution of renovation works	MOW	Yes, as a file
Acoustic soft-sensor	The tool is an innovative soft-sensing system for buildings' acoustic comfort measurement that uses a simulation-based approach and/or measured data. It allows assessing the acoustic comfort before building envelope renovation interventions and its improvement due to potential renovation scenarios.	Existing building data acquisition, Performance analysis, Execution of renovation works	UNIVPM	Yes : IFC acoustic parser proxy
3DASH tool	The 3DASH tool automatically detects and creates BIM entities from 3D point clouds acquired by laser scanning or photogrammetry systems. The tool supports the creation of As-Built models using point clouds as data for the generation of BIM models using REVIT software. This specifically tailored plug-in for REVIT is programmed in C++ and supported by the Point Cloud Library (PLC) as a standalone, large-scale, open software project for image and point cloud processing. 3DASH can precisely display the detected features in a unique working project (RVT/RFA). The PCL has a wide range of statistical algorithmic to detect geometrical primitives such as planes, cylinders, spheres, or cones. The tool reduces time in both the generation of As-Built models and comparing them to previous existing models, or the generation of these models without previous documentation. Additionally, the tool gives a high accuracy through a mathematical process based on algorithms for the detection and generation of walls using point clouds.	Existing building data acquisition, Renovation design	CARTIF	Yes

Application for crowdsourcing inhabitants' input	This app collects data on existing Buildings from inhabitants through a questionnaire that is available on a free downloadable mobile app. The app makes it possible to collect building data that is personal or subjective, such as experienced comfort level, from building inhabitants. Furthermore, the crowdsourcing approach allows to collect building data about the building conditions without the effort of inspectors, and without having to enter private homes to do an inventory. This tool makes it possible to relate collected building data to spaces in a BIM model, which allows new kinds of analysis. The collection of subjective inhabitant perception data is greatly simplified. The data collection process can be parallelized and thereby reduces time and effort significantly. New kinds of analysis through BIM 3D mappings allow for computer automation, and thus, potentially better insights with less effort.	Existing building data acquisition, Execution of renovation works	DEMO	Yes
BACN2BIM	The BACN2BIM tool allows users to collect information from sensors (dynamic data) installed in buildings and download this data from the BIM-Speed platform. The tool allows inserting information about the Building Automation Control network into BIM models through IFC. Users do not need to connect to other external IoT platforms to download the required data. Instead, they can download dynamic data from the building directly from the BIM-SPEED platform. All the information relative to dynamic data about the behavior of the building is also available to be used by users in other tools such as Building Energy Performance Simulation. The tool provides the addition of relevant information about the monitoring system installed on the building in the .ifc file.	Existing building data acquisition, Execution of renovation works, Occupation and maintenance	CARTIF	Yes
BEM calibration procedure	This is a procedure/tool for the calibration of BEM to guarantee an adequate level of accuracy and then to achieve a reliable performance prediction in the renovation design. It includes a plug-in for REVIT which makes easier the generation of the building model using 3D point clouds. The main benefits for the users are: time reduction in BEM calibration, increasing accuracy of the BEM, increasing accuracy of saving calculation of different energy retrofit measures/scenarios, encouraging BEM calibration in the building energy performance simulation.	Performance analysis, Execution of renovation works	UNIVPM	Yes
BIM Maturity Tool	The BIM maturity tool is an online tool that scans the BIM maturity level of your company through a questionnaire and provides guidance on what should be improved to achieve specific goals in a renovation project, such as reducing energy consumption or increasing the comfort level. The tool is designed for anyone involved in renovation projects that are interested in implementing BIM-based methodologies.	Existing building data acquisition, Renovation design, Performance analysis, Execution of renovation works	PB40	Yes

BIM Passport	The BIM passport gives an opportunity for workflow integration by marking information requirements, checking models, and assessing models. IFC LOD Lifer will be used in connection to the BIM Object Library database if a model assessment is not approved. This tool will offer a view of what data is available in relation to their building. The quality of the data is another aspect that the BIM passport gives an insight on. This tool benefits the users in time reduction due to the way it will not go through all the documents one has to see the quality and quantity. Also, financial, because the owner will invest in data that will be relevant, and not redundant.	Renovation design, Occupation and maintenance	ARC	Yes
BIM-SPEED BIM library	BIM-SPEED BIM library encompasses the BIM-SPEED database covering several materials and components useful for energy-efficient renovation of buildings. In the library, different building components can be viewed and selected for renovation design. The components can be downloaded in BIM formats. The library collects a set of parameters and files (BIM models, technical sheets, pdf, etc.). The parameters are divided into four packages: the "Info package", the "Energy package", the "LCA package" and the "LCC package". The tool's impacts are time reduction, carbon footprint reduction, and energy reduction.	Renovation design	STRESS	Yes
CYPETHERM Eplus	CYPETHERM Eplus tool is designed to provide thermal simulations and analysis using a BIM model. It is based on the Energy Plus calculation engine and generates detailed reports on a building's energy performance throughout the year based on the climatic data of its location. Modelling and energy simulation of buildings with EnergyPlus™ is integrated with the Open BIM workflow via IFC. EnergyPlus ™ is a calculation engine developed by the Department of Energy of the United States of America (DOE), is one of the most used, powerful, and recognized energy simulation engines of today. Thanks to its integration in CYPETHERM EPlus the application becomes a powerful tool for the energy simulation of buildings, allowing to know the energy demand, as well as the energy performance of AC systems, energy consumption by system, and energy vector used.	Performance analysis, Execution of renovation works	CYPE	Yes
ECOtool	The ECOtool automatizes the calculation of economic indicators related to the occupation and maintenance phases of the building renovation process. The tool is prepared to automatically calculate a set of indicators such as Operational Energy Costs, Investment, Life cycle cost, Return of Investment, Payback Period, and Operational Primary Energy Demand. It uses static data (IFC, energy bills), and dynamic data (energy consumption, energy costs) of the building. It counts on processes and ETLs to automatically obtain the required inputs from heterogeneous data sources. OpenAPIs are used to obtain information from the BIM-SPEED Platform and ThingsBoard IoT Platform within it.	Existing building data acquisition, Performance analysis, Occupation and maintenance	CARTIF	Yes

GIS data provider	This service supports the collection of surrounding geospatial and environmental data within a specific radius around the demonstration site. It retrieves surrounding data based on the location of the building extracted from the BIM (IFC) of the building. It offers a better understanding of the limitations and opportunities in the construction site prior to the analysis. This tool reduces time and costs. Through this tool users can extract relevant datasets only by selecting the demonstration site and downloading the relevant datasets. The conventional approach includes searching the required datasets for different stages of the building renovation, going through all available GIS data sources from public and private organizations to retrieve the relevant datasets, and pre-processing the huge datasets of cities to extract data for a specific buffer around the building. Additionally, knowing in advance about the limitations in the construction site helps to design the process with less cost for instance for data collection method selection.	Existing building data acquisition, Renovation design	TUB/CSTB	Yes
IFC4Acoustic parser service	A specific ETL (Extract, Transform and Load), to connect the Acoustic tool to the BIM- SPEED platform. This ETL performs an automatic parse between the BIM model and the Acoustic tool, using an IFC file as input (IFC4: ADD2-TC1 schema version) and generating an output in JSON that will be used by the Acoustic tool and will connect through an API. This tool reduces time and improves the accuracy of the results compared to traditional methods because no user iteration is required to obtain the necessary data.	Existing building data acquisition, Performance analysis, Execution of renovation works	CARTIF	Yes
KPI Dashboard	This tool collects (1.) evaluation preferences considering environmental, social, and economic aspects, (2). Different renovation scenarios (3.) KPI results from preceding tools regarding energy simulation, lighting simulation, acoustic simulation. The user gets a comparative overview of his renovation scenarios according to KPIs results and ranking considering preferences. In the KPI dashboard information and results from the preceding simulation and calculation tools and from the Multicriteria decision-making tool (No. 19) are collected. It will allow the display of different renovation scenarios and by that enable a holistic performance assessment.	Execution of renovation works	MTB	Yes
MEREEN weather service	This tool facilitates the collection of surrounding built and natural environmental data and the collection of historical actual weather data. The data is retrieved from the closest weather stations to the demonstration sites, or from the IFC file of the building. The ready-to-use information provided is essential for building energy simulations. The collected data can be used for example, for calibration purposes.	Performance analysis, Execution of renovation works	CSTB	Yes

Material Service	This service can be applied to an IFC file from the platform. It processes the file, investigates the materials that are named in the IFC file, and adds materials' details required for thermal simulation (thermal conductivity, Mass density, emissivity, etc.) in an augmented IFC file (initial IFC + material details information) generated as output to be used by simulation tools. The Material Service makes simulation condition setups easier.	Performance analysis	CSTB	Yes
Naming convention tool	This tool facilitates the implementation of file naming conventions in the project. The tool allows the creation of the rule for a file naming convention for each project. It also checks and warns if the file name does not match the file naming convention rule. It is very simple to use and convenient to synchronize files and manage different versions. The naming convention service makes it possible to assign a naming convention created by end-users to specific folders of their projects. Anytime a file is synchronized with a folder that has a naming convention assigned, the system checks that the synchronized file is properly named. It raises a visual alert sign if the document is insufficiently named. The user can then use the user interface to rename the file according to be applied naming convention. However, this tool does not allow to force a naming convention for synchronized files.	All building stages	CSTB	Yes
Thermal Texturing of BIM	Volumetrization Techniques, Thermal Texturing of BIM tool (VT1 tool) is a technique of producing 3D thermal models from the 2D thermal scans and the CAD model of the building. This technique does not require knowledge in 3D modelling as even the basics are easy to navigate. This tool provides visualization of the thermal situation, which is of higher usability than the 2D scans.	Existing building data acquisition	ASP	No: not an online service
Thermal photogrammetry	Volumetrization Technique, the Thermal Photogrammetry tool (VT2 tool) is a method of volumetrization of the 2D thermal scans. The process takes advantage of photogrammetry but requires some adjustments and special requirements of the 2D thermal scans. The workflow begins with 2D scans, adjusting them, passing through photogrammetry, and finally receiving a 3D thermal model. This tool provides visualization of the thermal situation, which is of higher usability than 2D scans.	Existing building data acquisition	ASP	No: not an online service
VR tools for presentation for owners and clients	Virtual Reality applications (for Android devices and iPhones) in VR boxes for presentations of solutions for renovation, addressed to owners and clients.	Renovation design	ASP	No: not an online service

VR, AR/MR	XRT1 EXTENDED REALITY TECHNOLOGIES SET, PART 1 AUGMENTED REALITY – MICROSOFT HOLOLENS 2	Renovation design	ASP	No: not an online service
	XRT1 tool is a methodology for creating holograms from BIM and photogrammetric models by the game engine Unity. It allows users to visualize by Microsoft HoloLens 2 for different renovation scenarios, comparing the existing building with the variants of design solutions. The tool is supported by a primary file with all the needed settings for importing BIM and photogrammetric models.			
	XRT2 EXTENDED REALITY TECHNOLOGIES SET, PART 2 VIRTUAL REALITY – OCULUS QUEST			
	XRT2 tool is a methodology for creating VR models from BIM and photogrammetric models by the game engine Unity. It allows users to visualize by Oculus Quest 2 different renovation scenarios, comparing the existing building with the variants of design solutions. The tool is supported by a primary file with all the needed settings for importing BIM and photogrammetric models.			
	XRT3 EXTENDED REALITY TECHNOLOGIES SET, PART 3 VIRTUAL REALITY – VR BOX AND ANDROID / IOS			
	XRT3 tool is a methodology for creating VR models from BIM and photogrammetric models by the game engine Unity. It allows users to visualize by VR Box and Android device or iPhone different renovation scenarios, comparing the existing building with the variants of design solutions. The tool is supported by a primary file with all the needed settings for importing BIM and photogrammetric models.			
	XRT4 EXTENDED REALITY TECHNOLOGIES SET, PART 4 AUGMENTED REALITY – 3D ANAGLYPH GLASSES			
	XRT4 tool is a methodology for creating desktop AR models from BIM and photogrammetric models by Unity, using Holo SDK. It allows users to visualize by 3D anaglyph glasses at front of the desktop different renovation scenarios, comparing the existing building with the variants of design solutions. The tool is supported by a primary file with all the needed settings for importing BIM and photogrammetric models.			
	XRT5 EXTENDED REALITY TECHNOLOGIES SET, PART 5 AUGMENTED REALITY – MOBILE			
	XRT5 tool is a methodology for creating mobile AR models from BIM and photogrammetric models by the game engine Unity. It allows users to visualize by an Android device or iPhone different renovation scenarios, comparing the existing building with the variants of design solutions.			

5. BIM-SPEED account for the BIM-SPEED team

This paragraph describes technical adaptations and support actions which have been performed so that BIM-SPEED end-users, competition members and BIM-SPEED consortium partners could get connected to the platform to understand it, use it, and later request "informed" technical evolutions according to BIM-SPEED-defined use cases.

The KROQI workspace dedicated to BIM-SPEED can be accessed at: BIM-SPEED.kroqi.fr

5.1 BIM-SPEED workspace structure: platform organization setup for BIM-SPEED partners

When using the KROQI platform, any user can create workspaces of which he becomes the manager. That said, CSTB has created a workspace dedicated to BIM-SPEED where all the demonstrators of the project were managed. The features and services specific to BIM-SPEED were integrated into this workspace and were not visible to users in other spaces. On the contrary, third-party services offered to French users of the platform have been excluded from the BIM-SPEED space, at least in this launch version.

As detailed in Appendix 1, a workspace is composed of projects that can be grouped into categories (e.g. to group all projects of the same country).

A project is composed of files (documents, models…) that can be grouped into directories (folders).

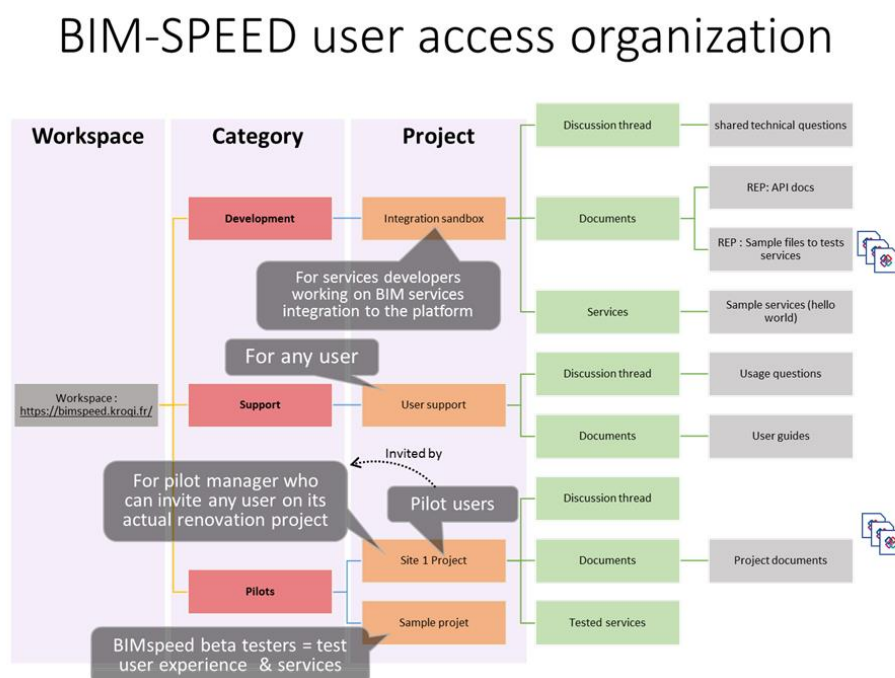The following figure shows the initial structure of the BIM-SPEED workspace.

Figure 26.   BIM-SPEED workspace structure

Within the BIM-SPEED workspace the following projects have been created:

▪ An **integration sandbox project** which is meant to exchange technical information and make tests with services developers (DEV zone only ...);

▪ A **user support project** where all documents related to the "user experience" of the platform were accessible. This project is about end-user support;

▪ As projects:

  - a **sample project** *where any BIM-SPEED user can test and experiment BIM-SPEED collaboration & services (when integrated), like a demo project.*

  - **actual BIM-SPEED pilot sites projects** *where any partner in a renovation project can use the platform to carry out his/her projects.*

5.2   Accounts and roles

User accounts are created at the workspace level. A user account is associated with a role (or rank) giving different rights: administrator, project manager, and user. Users can be created by managers or administrators. The various roles are synthesized below.

Figure 27.   Workspace roles and associated rights

Roles/Ranks	Rights
Workspace Manager	He/she is the creator of the workspace. Only one person has this rank in a workspace. He/she is the master of all access and management rights on all projects of his/her workspace. In particular, the workspace manager can create projects in this workspace.
Administrator	He/she has the same privileges as the Workspace Manager. Only the workspace manager and an administrator can create another administrator.
Project Manager	He/she has privileges limited to the projects for which he/she has been invited. In particular, he/she can invite users to participate in his/her project and define their access rights to the various project folders. He/she can also create new projects.
User	He/she has no privilege, either on the workspace or on the project. He/she can only participate in projects for which he/she has been invited.

To create a user account, the following data is requested: first name, last name, and email address.

All user accounts created in a workspace are registered in the workspace address book. Only privileged users (workspace managers and administrators) have access to it.

For the launch version of the platform, members of the BIM-SPEED consortium have been asked to mention the role they would play in the project to assign them rights and give them access to the folders corresponding to their activities.

- **Dev**: to get access to the Dev Sandbox project
- **Tester**: to get access to the Sample project
- **BIM-SPEED pilot site leader**: to manage one (or several) Pilot project(s) and be able to invite anyone of your choice to this project space.

5.3   Document management

Successive versions of a given file are stored by the platform. By default, the latest version is accessed when accessing a file, but it is possible to select a former version by choosing it among the list displayed on demand.

The platform ensures the traceability of all downloaded documents.

A document can be the subject of a validation workflow.

Keywords can be added to a document to facilitate searching.

It should be noted that folders (or directories) can be shared with people outside the project to allow them to access documents in this folder without having to create new accounts on the workspace. It is also possible to allow third parties to upload documents to the platform.

6. Conclusion

The BIM-Speed platform's intention is to provide a flexible basis for the renovation market in Europe that requires a high diversity and flexible to support the specific requirements of renovation projects characterized by high diversity and a wide variety of needs and practices across EU member states and European districts. To support this end, the BIM-SPEED platform allows to flexibly integrate a variety of services (desktop and online applications) through an open store. This is demonstrated through the integration of different renovation applications developed within the BIM-Speed project. Additionally, the platform allows to flexibly integrate with other existing BIM platforms. This possibility to integrate with other ecosystems is illustrated by the implemented connection to two different platforms, such as the CYPE BIM-server and the facility management suite of project partner Demo.

As far as features are concerned, the final version of the BIM-SPEED cloud platform provides document management and teamwork functionalities that are at the heart of collaborative activities. **It integrates more than 20 functional renovation-oriented services that were used by BIM-SPEED users during the project. Interoperability features from WP5 services have been integrated into the platform to ease data exchange**.

The ambition of the platform is now to become a marketplace where construction stakeholders can collaborate and choose the renovation services that are useful for their work.

The BIM-SPEED platform is based on the KROQI platform which is already in production. **CSTB will create at the end of 2022 a spin-off company to manage the KROQI platform.**
This new entity can be used to valorise BIM-SPEED platform technologies & services by i) leveraging KROQI production infrastructures & staff, ii) extending KROQI business model to BIM-SPEED integrated services.
BIM-SPEED platform business model aspects are detailed in BIM-SPEED exploitation plan deliverable which takes this context into account.

APPENDIX 1 - EDMS REST API (routes summary)

This list is extracted from the document edms-server.pdf available in the 'Integration sandbox' project of the BIM-SPEED workspace at.

https://BIM-SPEED.kroqi.fr/#/integration-sandbox/documents/?directory=58856847

- /
- /about
- /api/1.0/edms/account
- /api/1.0/edms/account/user
- /api/1.0/edms/account/user/{user_id}
- /api/1.0/edms/account/users
- /api/1.0/edms/accounts
- /api/1.0/edms/auth
- /api/1.0/edms/login
- /api/1.0/edms/logout
- /api/1.0/edms/projects
- /api/1.0/edms/projects/{project_id}
- /api/1.0/edms/projects/{project_id}/docs
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/comments
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/comments/{comment_id}
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/content
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/path
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/protocols
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/protocols/{protocol_name}
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/protocols/{protocol_name}/validation
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/tags
- /api/1.0/edms/projects/{project_id}/docs/{doc_id}/updated
- /api/1.0/edms/projects/{project_id}/events
- /api/1.0/edms/projects/{project_id}/folders/{folder_id}
- /api/1.0/edms/projects/{project_id}/folders/{folder_id}/index
- /api/1.0/edms/projects/{project_id}/folders/{folder_id}/path
- /api/1.0/edms/projects/{project_id}/folders/{folder_id}/protocols
- /api/1.0/edms/projects/{project_id}/folders/{folder_id}/protocols/init
- /api/1.0/edms/projects/{project_id}/index
- /api/1.0/edms/projects/{project_id}/users
- /api/1.0/edms/toast
- /health
- /version

APPENDIX 2 – BIM-SPEED platform Teamwork functionalities

Several tools are available for teamwork at the core of the BIM-SPEED platform:

Agenda and events

The agenda includes the tasks, meetings, and other events of the project. It comes in the form of a classic electronic agenda.

When planning a meeting, it is possible to invite external participants to the project.

Tasks

The platform allows the creation of project-specific tasks. Tasks allow you to request a document or service from one or more users of the project. It is possible to break down a task into elementary subtasks. This function is very useful to trace the progress of solving the task. It is also possible to associate a manager with a subtask.

Chat

Chat is an instant chat tool. This is the best way to have a private chat with another project participant without overloading your mailbox. A chat can be initiated with a group of users (i.e. a discussion group). When you have new messages in the chat, you receive a notification on the platform as well as in your working environment with the KROQI Drive installed.

Messages

The messaging functionality allows you to simply send an email from the platform to one or more project participants.

AirTime

The AirTime tool makes it easy to organize audio and video conferences. You can invite up to 4 participants whether they are part of your project or not. If they are not part of your project, you must send them an email to tell them the conference link.

It should be noted that AirTime is not yet supported by all browsers (incl. Internet Explorer), and that some functionalities (like screen sharing or notifications) are not yet implemented for some browsers (see Appendix 1 for more details).

KROQI Drive

KROQI Drive allows users to create a space on their personal computer (MAC or PC) where a copy of the content of all or part of the projects in a workspace is stored. This software ensures file synchronization: You can upload files to your Drive and the online workspace is automatically updated.

If someone deposits or modifies a document, on the platform or from their own Drive, a message warns you of the change.

It should be noted that a maximum of 3 synchronized workspaces can be managed on KROQI Drive.

APPENDIX 3 - Differences between the BIM-SPEED platform and the KROQI platform

This paragraph presents some of the differences between the BIM-SPEED platform and the KROQI platform reviewed **at M24**.

Feature or service	Description	Pre-existing within KROQI	Improved, updated or created within BIM-SPEED project	Description of BIM-SPEED work	Provided to KROQI users	Provided to BIM-SPEED users
Sample third-party service	Sample integrated service to provide an example for BIM-SPEED consortium developers.	no	created	Creating & documentation of a structured sample service	Yes	yes
Profiling service	This service makes it possible for the BIM-SPEED administrator to create sets of services (profiles) which can be assigned to chosen accounts so that a set of services can be selectively made available to groups of users. This is useful in BIM-SPEED project to be able to expose BIM-SPEED integrated services only to BIM-SPEED projects users. Up to the exploitation phase decisions, BIM-SPEED services were be exposed to KROQI users. See A.3.1 for details.	initiated	finalized	The concept of profile to group set of services was prototyped during the KROQI Project (initial basic prototype). Administration profile service was finalised and put in production during the BIM-SPEED project with the goal of segregating BIM-SPEED set of services from KROQI set of services. This work made it possible to expose BIM-SPEED services to BIM-SPEED users without mixing them with KROQI services.	Yes (Outcome of BIM-SPEED effort)	yes

Semantic BIM checker	Semantic model checker is meant to check IFC models against a set of predefined checking rules. Ontology and linked data related research about rule checking were initiated by CSTB in research projects preceding the BIM-SPEED project. BIM-SPEED project effort focusses on improving the technical internals of the checking service and putting it in production for BIM-SPEED users.	yes	Improved software BIM-SPEED Dedicated checking rules	• Service core features improvement (IFC processing technique, SparQL rules management features etc.) • Modularisation of the service for BIM-SPEED workflow integration • Improved deployment process in production (GCP) • Specific BIM-SPEED checking rules created during the project (ex: Cype rules see A.3.2)	yes	yes
BIM-SPEED workflow system	The BIM-SPEED workflow system has been created to allow folder-based automations: users can install predefined folder templates that help them to trigger renovation services while using the EDMS. When files are dropped in automated folders, BIM-SPEED services can be automatically triggered. See A.3.2 for details.	no	Created	• BIM-SPEED workflow use cases definition • BIM-SPEED workflow technical design and implementation • BIM-SPEED workflow deployment on development, qualification & production platforms • BIM-SPEED workflow support for BIM-SPEED partners	To be seen on case per case basis	yes
Integration of BIM-SPEED partners services	Integration of BIM-SPEED services in BIM-SPEED platform	No	created	• BIM-SPEED support services integration use cases definition • BIM-SPEED services technical integration support (for BIM-SPEED partners development teams) • Integrated services (non exhaustive): GIS service, weather service, BACN2BIM (linking IoT data to BIM), "Material" service (enrichment of IFC4 files with material properties), Cype ecosystem's proxy application etc…	To be seen on case per case basis	yes

Integration with sister projects activities	Integration in BIM-SPEED of existing services/features from other H2020 sister projects (ex: BIM4REN)	no	created	• E.g.: integration of BIM4REN LODLifter application for BIM-SPEED users • Integration of Nobatek MassDoc service	To be seen on case per case basis	yes
Project structure management service	Helps users to implement predefined folder structures depending on their needs	Yes, in an embryonic version	improved	• now allows the embedding of predefined contents or predefined automations (cf. BIM-SPEED workflows) in the default template structures • needs to be improved to good prediction	no	yes
PKI integration service / dashboarding service	Automatically aggregates KPIs dropped by BIM-SPEED services in specific automated folders to compute aggregated high-level-KPIs to be displayed By Metabuild dashboarding system	no	created	• definition of the KPIs integration process with Metabuild • implementation of the integration process in the platform as an automated service	no	Yes
Competition service	Creation of a competition service to enrol KROQI users to the BIM-SPEED competition and turn their KROQI account into a BIM-SPEED account presenting BIM-SPEED services	no	created	• creation of the user enrolment service • creation of the administration interfaces to help BIM-SPEED competition organisers to manage the user enrolment	yes	yes
Centralized user data management service	Service which makes it possible for the end-users to "opt-out" and delete from one place data that has been shared with various services from BIM-SPEED vendors for a BIM-SPEED project.	no	created	• envisioning and design of a service • implementation of a service in the platform • communication with the service providers for tests	Yes, in the future	yes

Dynamo scripts for correctitude of modelling	Two Dynamo scripts can be used to examine that all the required equipments are modeled and that all valves are placed in the correct position. By using this tool BIM modelers will save time by not having to conduct manual inspections or use other software to make sure the equipments were modelled in the correct room, and if all the valves have been placed or if they are missing.	Existing building data acquisition, Renovation design	ARC	No this is not an online service: these are custom scripts they could be provided as files in the platform
Comfort Eye	The "Comfort Eye" is an innovative IEQ monitoring system for assessing building performance. IT communicates in real time and, it provides a measure of thermal comfort (according to ISO7730 and ISO7726), IAQ, visual comfort, and thermal images of the indoor environment. Thermal and acoustic comfort are important quantitative parameters that are linked to the wellness of inhabitants. The knowledge of those levels is important, especially for the inhabitants. Additionally, the identification of rooms with bad thermal comfort can be connected also to the lack of energy saving.	All building stages	UNIVPM	No because it is not a full online application + it relies on in-place sensors installation
Lighting and visual comfort analysis	Climate Studio, Revit, Rhino+ Grasshopper: Industry-based energy and comfort tool with LEED, BREAM, WELL certification compatibility, and verification. The added value of Climate studio is the in strong visuals, user customization, accreditation measurements, extensive artificial light library, speed of simulations, expansion with Grasshopper, and Melanopic readings.	Performance analysis, Execution of renovation works	UNSTUDIO	No based on external tools
BIMtoBEPS	This tool addresses the interoperability between BIM models contained in IFC4 files and building energy modelling using TRNSYS 18 as a simulation engine. Specifically, the building energy model is generated according to the data input file (*.b18) structure associated with the TRNSYS Type 56 that can be manually generated using the TRNBuild user interface in a process that tends to be time-consuming and error prone. This tool allows the automatization of the BIM to BEM process reducing time in the generation of BEM models.	Performance analysis	CARTIF	No: very specific desktop BEM component.
BEM Generator	The Simple BEM generator is a tool to create a computable BEM without the input of an existing BIM. It is especially useful to conduct initial fast simulations and optimization procedures to create an overview for a project without BIM. As creating a detailed BIM is often a lengthy process, these initial results help to decide whether a specific project is worth the effort or whether another project might have a greater potential for improvement. This tool is not part of the standard BIM- to-BEM project process but it is a "bonus tool" that can be used at an early stage. The tool creates a simplified BEM that may be used for an initial analysis. The model is not calibrated according to consumption data. Instead, standardized assumptions of use schedules and consumption are applied. The tool offers a low-barrier entry into BIM and specifically simulation by usability for non-experts with minimal user effort involved. The user of the BEM Generator (simplified) are planners, architects, and building owners.	Performance analysis, Execution of renovation works	MTB	No: could be easily done later