BIM Execution Plan for residential deep renovation

Deliverable Report D7.6

Deliverable Report: D7.6, issue date on 11.11.2022

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

This research project has received funding from the European Union's Programme H2020-NMBP-EEB-2018 under Grant Agreement no 820553.

BIM Execution Plan for residential deep renovation

Deliverable Report D7.6

Issue Date	11.11.2022
Produced by	MOW, PB40
Main author	Christopher Kowal (MOW)
Co-authors	Josephine Cooke (PB40), Essam Fadel (PB40)
Contributors	VISESA, TUB, ARCADIS, ASP, STRESS, FASADA, DEMO, CSTB
Version	1.0
Reviewed by	Serena Serroni (UNIVPM), Josephine Cooke (PB40)
Approved by	Timo Hartmann (TUB)
Dissemination	Public

Colophon

This research project has received funding from the European Union's Programme H2020-NMBP-EEB-2018 under Grant Agreement no 820553.

Change log

Description	Author	Date
Initial version for internal review	Christopher Kowal	30.09.2022
Internal Review	Josephine Cooke (PB40) Essam Fadel (PB40) Serena Serroni (UNIVPM)	14.10.2022
Addressed internal review comments	Christopher Kowal	21.10.2022
Finale editorial review	Samaneh Rezvani (DMO)	31.10.2022
Publication of the open repository for BEP of demo cases	Timo Hartmann	10.11.2022
Inclusion of the repository link tot the summary	Samaneh Rezvani (DMO)	11.11.2022

Publishable executive summary

The use of BIM has been increasing in prevalence within the construction industry, however it is still lagging behind in the field of renovating existing buildings. It has the potential to improve the renovation process and to help alleviate the bottlenecks that prevent more buildings in Europe from being deeply renovated. However, for this to have the highest probability of success, project participants should adhere to principles of Integrated Project Delivery and proper information management and coordination. The following report describes information management according to the ISO standard 19650 from the procurement stage to the operational coordination stages, including how to incorporate and prepare a BIM execution plan for a given project. Furthermore, the health, safety, and environmental management aspects are explored. Expanding upon task T5.4, the process of integrated project delivery is described with a focus on its relation to BIM execution plans. A generic BEP template was created based on ISO standard 19650. Practical examples using this template based on BIM-SPEED demo sites were generated, including renovation projects of various building types and scales. The results are published here and are openly accessible. This repository shares the template and 13 implemented BIM execution plan examples for all the BIM-Speed demonstration project. The repository will help researchers on improving on BIM execution planning and practitioners to devise specific plans for their projects.

This report is targeted towards parties involved in or interested in deep building renovations who can stand to benefit from the use of BIM and may use the developed examples and template in their projects.

List of acronyms and abbreviations

BEP	BIM Execution Plan
BIM	Building Information Model
CDE	Common Data Environment
EIR	Exchange Information Requirements
IPD	Integrated Project Delivery
LOD	Level of Detail
LOIN	Level of Information Need
HSE	Health, Safety, and environment
OIR	Organization Information Requirements
AIR	Assest Information Requirements
PIR	Project Information Requirements

Definitions

Appointed party

The party that is responsible for delivery or creating information. An example would be a designer or subcontractor. A **Lead** appointed party is responsible for project delivery to the client, or the main appointing party. A general contractor may take the role of a lead appointed party

Appointing party

The party that is to receive information from an appointed party. This may either be the client or the general contractor in relation to its subcontractors.

Classification system

Classification systems in the context of BIM refer to the common language of parameters that is used in a project which allows for the data to be used efficiently by project participants.

Federation strategy

A strategy to break the model down into substructures to allow for more efficient collaboration between task teams.

File naming conventions

A system to name and sort the files used within a project.

Post-contract BEP

A BIM execution plan which is updated following the signing of the contract.

Pre-contract BEP

A BIM execution plan prepared in the tendering phase before the signing of the contract.

List of Figures

List of Tables

Contents

1. Introduction

1.1 Description of deliverable content and purpose

This deliverable provides an overview of information management and integrated project delivery in the context of BIM with a focus on providing practical information on their potential use within renovation projects. The report begins by introducing information management, or in other words, how information is exchanged, produced, and the requirements for a given project. It is the foundation of a BIM-based project and needs to be accounted for early on in the planning process. Integrated project delivery emphasizes the need for the proper organization and integration of project participants in order to meet the goals of the project as efficiently as possible. An overview of the implementation of these ideas in the procurement and operational coordination phases of a project are provided in this deliverable. Included are BIM execution plans that were created based on all BIM-SPEED demo sites.

Purpose

The purpose of this deliverable is to provide relevant background information about BIM execution plans which is necessary to understand how and why each aspect of the plan should be included in the document. With this knowledge, prospective employers and bidders of BIM-based renovation projects will have a better understanding and ability to implement BIM in a thought-out and efficient manner. Along with developed BIM-SPEED tools, which can be included within a BEP, the barriers to BIM implementation in renovation projects can be lowered in order to increase adoption within this sector.

Scope

This deliverable will include examples from projects of various sizes and types, showing that a BIM execution plan can be implemented on smaller projects, such as the renovation of a single-family home.

Target Group

The target group of this document are all parties involved in a BIM-based renovation project, including employers and contractors as well as designers and other participants. In particular, public authorities and clients which wish to educate themselves about a BEP and its creation are addressed. Also, parties interested in Integrated Project Delivery (IPD) and willing to make use of the method in a BIM-based renovation project are addressed. This deliverable also hopes to motivate those that would be otherwise hesitant to include BIM or BEPs in their project, and to show that it is beneficial and that it is not a difficult task.

1.2 Approach and contribution of partners

Before work on demo site BEPs began, a standardized BEP template was created based on the standard ISO 19650. This relatively new standard is based on and has come to replace the British PAS 1192-2:2013 for information management, which is included in the description of action as it was still

the prevailing norm when it was written. The standard was analyzed in order to create the template, which was then used as a basis for creating BEPs for each BIM-SPEED demo site. Meetings were held with each demo site partner separately in order to explain and guide them through the process of writing each BEP. As each demo site had a different level of BIM implementation or stage of renovation, the BEPs attached to this deliverable should not be taken to be real contractual documents, but should serve an educational role to show how a BEP could be written.

Contribution of partners

The contribution to this deliverable by partners is shown in Table 1.

#	Partner	Contribution
1	MOW	Leader of the deliverable, coordinator of the overall task activity. Contribution to information management and BEP (operational coordination) sections of deliverable. Preparation of BEP template and BEPs for Warsaw I and Warsaw II demo sites
2	PB40	Contribution to procurement and integrated project delivery section of deliverable.
3	VISESA	Preparing BEP for the Vitoria demo site
4	TUB	Preparing BEPs for the Lichtengrade and Tempelhof demo sites
5	ARCADIS	Preparing BEP for the Barlad demo site
6	ASP	Preparing BEPs for the Malko Tarnovo and Varna demo sites
7	STRESS	Preparing BEP for the Frigento demo site
8	FASADA	Preparing BEP for the Gdynia demo site
9	DEMO	Preparing BEP for the Warmond demo site
10	CSTB	Preparing BEPs for the Antony and Massy demo sites

Table 1 Partner Contribution

1.3 Relations to other tasks

Based on the BEP template, in collaboration with WP8, BEPs were created for real projects on each BIM-SPEED demo site. Part of creating a BEP is to define the scope of a project, which relates to WP2. The BEPs contain information on the BIM-SPEED tools that were implemented in each demo site (WP4, WP5) as well as how the BIM-SPEED platform was utilized (WP6).

2. Information management

The basis of all projects, including renovation projects, is the information that is acquired, produced, and exchanged by all parties involved. The manner in which this should occur in a BIM-based project is outlined in the international standard ISO 19650, which has taken over and adopted many elements of existing British standards. The norm recognizes the importance of proper management and handling of information as well as the need for cooperation between participants for this to be possible. This idea is further discussed in the section on *Integrated Project Delivery*.

Information at its core, is data which can be structured, such as a 3D building model, or unstructured, including photos, videos and documents. It must be managed in such a way that minimizes the need for corrections and so that the parties receive the information they need at the correct moment in order to continue progressing work on a project. The information needed must be specified ahead of time, as well as who is responsible for it and who will be on the receiving end. An important aspect which the norm highlights, is to avoid over-producing information as this creates unnecessary work for both the party creating and receiving it, as there is more information to sift through to obtain what it needed. This prevents confusion during the delivery stage of the projects as well as unnecessary delays.

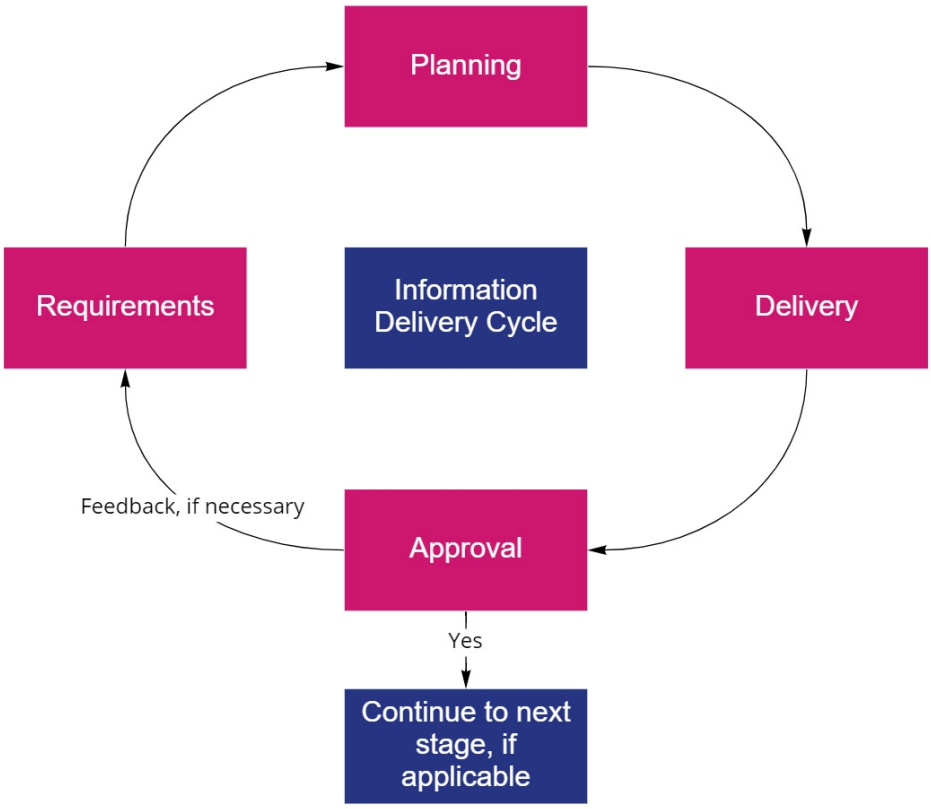

Figure 1 Information delivery cycle (Source: MOW, based on ISO 19650-1)

The first step in information delivery is to create relevant information requirements based on assumptions and goals. These requirements form the basis of each subsequent step from planning

to final approval of the deliverable. Delivery plans are then created determining deadlines and outlining how the requirements are to be met. Unless the information is approved upon first delivery, this becomes an iterative cycle, where feedback is provided and either the requirements are updated, plans revised, or

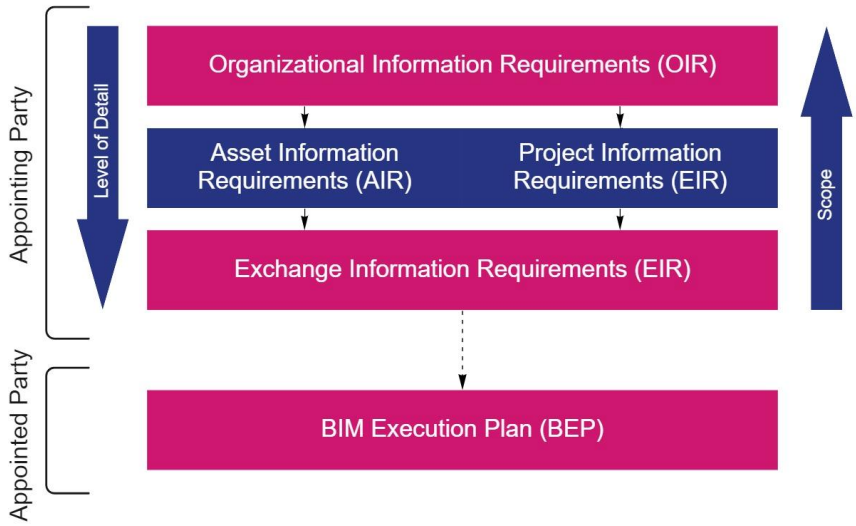

Figure 2 Types of information requirements (Source: MOW, based on ISO 19650-1)

simply the deliverable must be resubmitted for approval. Information is submitted by the lead appointed party, who must gather and check information from other appointed parties such as subcontractors or other team members, if applicable, in order to submit a complete deliverable. Once final approval is obtained from the appointing party, the next stage of a project may begin. It is recommended, however, that between project stages, especially when information is handed over from one party to another, that the information be rechecked.

The standard specifies several types of information models and information requirements based on what level of a project is being considered. In the broadest sense, it is recommended to establish information requirements at the organizational level (OIR). This includes the high level information an organization needs for strategic planning. This then goes on to guide the requirements set out for asset information (AIR) and project information (PIR). PIR set out the requirements relating to asset delivery while AIR set out requirements for the asset during its operational stage. PIR and AIR influence each other, meaning that in order to achieve asset objectives, the PIR must be able to accommodate for them. Having these higher-level requirements allows for the appointing party to be able to produce focused exchange information requirements (EIR). EIR are project-specific and detailed, and as the name implies, address the exchange of information in a project, such as what information must be delivered, when, and by whom. An EIR is sufficiently narrow in scope and contains enough details to be a used in the tender process as well as form a basis for a contractor to write a BIM execution plan for the project.

Specific instances of information requirements and those commonly included in BIM execution plans are further described in the section on *Operational coordination and BIM Execution Plan structure.*

3. Integrated Project Delivery

In order to facilitate proper information management between project participants, Integrated Project Delivery (IPD) is a necessary project delivery approach that aims at integrating "people, systems, business structures and practices into a process that collaboratively harness the talents and insights of all participants to reduce waste, and maximize efficiency through all phases of design, fabrication, and construction" [1]. In short, IPD promises to help deliver better buildings in shorter time. Its development goes back to concepts that have been derived from W. Edward Demings work with Toyota in the 1950s. He realized sustainable productivity improvements and management optimization under the use of systems thinking. IPD focuses on overcoming adversarial relationships which characterize the traditionally fragmented construction industry. Different IPD concepts have been developed, taking local requirements of both the demand and supply side of the AEC industry into account. A cornerstone of all IPD concepts is the idea to bring in the collective expertise of involved parties into a project as early as possible. A concept which could be extremely fruitful in renovation projects, because often construction companies undertaking renovation have many experiences with certain building typologies and their specifics and therefore can give valuable input right from the beginning of the design phase. Furthermore, two elements are frequently found in IPD contracts: a multi-party agreement in some form and a shared risk and reward component. IPD therefore provides a framework to integrate shared goals and values for the project participants and helps to reduce adversarial relationships that cost productivity and efficiency in traditionally organized construction projects. Apart from seeing IPD as a project delivery method, it can be defined as a strategy for procurement or a form of contract as well.

3.1 Basic Concepts

In the technical reports from AIA contract documents on integrated project delivery, different experts identified key elements that should be present in the context of IPD implementation, those are categorized in IPD markers and IPD strategies as follows[2]:

IPD Markers

- Relational Contracts
- Protection from litigation
- Aligned project goals (Jointly Developed Project Target Criteria)
- Informed and balanced decision-making (Collaborative Decision Making)
- Open Communication
- Risks Identified and Accepted Early

IPD Strategies

- Key participants bound together as equals (Multi-party Agreement)

[1] J. A. Wright (2012): p. 4)
[2] AIA Minnesota (2011)

- Budget & create team for design intensive work
- Early contribution of expertise (Early Involvement of key participants)
- Pre-existing relationships between parties
- Champion/ Facilitator (Leadership by All)
- Shared financial risk and reward based on project outcome
- Liability waivers between key participants
- Fiscal transparency between key participants
- BIM - virtual rehearsal of construction and ongoing constructability reviews
- Lean Construction processes
- Co-location

Each project has its own particularities and the delivery suitable for it depends on some of those particularities. Some experts pointed out the motivations for selecting and implementing IPD in a certain project:

- Market advantage: IPD may give valuable experience. Improving the delivery may also be a market advantage if measurable results can be attained. For serial owners, savings on one project done in IPD can be leveraged across many subsequent projects.
- Cost predictability: All projects would like to meet budget, however, for some the predictability of cost is a notably driving factor and IPD can reduce unpredicted over costs.
- Schedule predictability: Similar to cost, all projects share the goal of meeting their planned schedule, but for some projects this is a major issue.
- Risk Management: Reducing or managing risk can be tied with cost or schedule, but also may include transactional risk inherent to project type, site or other conditions. If risk management is a critical factor, the increased communication in IPD may be of particular advantage.
- Design Complexity: A high degree of complexity will usually demand integration of expertise and require a level of coordination that is achievable in an IPD environment. IPD sets up structures that make integration and cooperation more likely to occur than not.

3.2 Relationship IPD and BIM and renovation projects

As described above the application of IPD concepts focus on the fashion of how and when parties work together; meaning the definition of their relationships and responsibilities. In this segment this relationship is elaborated further; also, findings from BIM-Speed project arguing for a use of IPD for BIM for renovation projects are presented.

IPD and BIM

The relationship between BIM and IPD can be described as mutual reinforcing. Both IPD and BIM are innovations that require changes to processes and are driven by advances in technology and a redrawing of social relationships.

BIM is more connected with technology and its opportunities of exploitation, while IPD is more related to the reorganisation of the conduct of a project and its participants. They share the ideal of a free flow of information within a project and the close cooperation between the participants and different professions. Rowlinson states that "BIM is likely to slip from our lexicon, and we will just talk about IPD with BIM technology as merely an enabler of IPD" when their role out is successful.[3]

IPD for renovation projects

Within the elaboration of the *Guidelines for BIM-based procurement, collaboration protocols and IPD for renovation project* (BIM-SPEED-Deliverable Report 5.4) several experts that have been consulted pointed out, that they or their organizations see IPD (and related concepts) in combination with BIM as an attractive procurement route, especially for renovation projects. Recurring arguments supporting a role out of IPD for BIM for renovation included:

1) Construction expertise integrated early can reduce expensive redesign and changes at a later stage
    a. Early involvement of all important stakeholders into a renovation project, can help better the predictability of cost. E. g. a constructor involved early can give his experience on certain building typologies and common cost drivers; this can help shape the design for specific building types.
    b. Project goals can be checked against different professions experience.
    c. Early check of design by constructors may reduce often occurring design performance gap in renovation.
    d. The more complex a building or apartment block is, the more important is the integration of professions; the sooner the better.
    e. Projects schedules become more realistic when key participants draw them together.
2) Jointly described and decided project goals can enhance understanding and collaboration. As renovation can tackle a wide range of problems, it is relevant to include all important stakeholders to assess what kind of renovation they deem important and with link to existent resources (macroeconomic parameters, budget, time, skill etc.).
    a. A clear understanding of parameters and KPIs for renovation between all important participants help to concentrate resources.
    b. The co-creation of those goals ensures that participants can evaluate whether they are realistic from their profession's perspective, given the project budget etc.
    c. Project participants in an IPD lead project will gather more overall project information which may lead to market advantages in the future.
3) IPD-agreement gives the information flow and cooperation a legal framework which helps to overcome uncertainties that occur with BIM only because of the status quo in the industry of separation of design and construction phase. This is of particular interest for SMEs performing

[3] Rowlinson (2016, p. 48)

renovation who see legal risks with the application of BIM and need distinct agreements to overcome this hurdle.

a. Open discussions and agreements between participants that are needed to achieve 1) and 2) can only be successful when a legal bracket is formulated that compensate risks and rewards.
b. The same goes for sharing of information such as data models etc.
c. Efficient risk management depends on a sound and clear legal situation.

3.3 Legal aspects

Consulted industry representatives and professionals pointed out, that the legal situation regarding the application of IPD concepts is mostly unclear within the industry. This is because IPD tends to develop an integration of two traditionally separated procurement elements: the procurement of services (design) and the procurement of goods (construction). The common legal documents are bound and build on this traditional separation.

Some stakeholders are willing to take first steps to integrate both, e. g. implementation of an intermediate phase between design and construction phase in which the constructor can share his knowledge about construction which can lead to redesign. But the legal situation has to be analysed and assessed for each project and depends on country, organisation and local experience of procurement and design, construction staff. Nevertheless, a BIM for renovation project that completely integrated IPD concepts has not been found; at least not one in which experts were keen to share their knowledge for interview purposes. But pilot projects, from which others can learn is what is needed for an application of IPD concepts.

As an example, for the German situation Eschenbruch points out how common local legal situations contain aspects that can be used for an application for IPD-pilot-projects[4]. Elements that the author describes that are important for the application of IPD refer to shared leadership and decision-making committees; top priority for IPD is using all stakeholder's specific knowledge as early as possible and the integration of design and construction phase. This has to be built into legal arrangements. Eschenbruch analysed that IPD-contracts generally can make use of in Germany widely known and used project management concepts such as project lead, consultancy and decision-making committees. Although pilot project experience in Germany with IPD are hard to find, he describes that those concepts can be applied using traditional project management concepts, with the change of only integrating not only the owner but all – important stakeholders (main designer and main constructor) e. g. in the decision-making committee. For the formulation of a contractual arrangement within a project three different solutions are presented: Standard contracts with additional IPD general business terms, multi-party-contracts and realization via a project specific company. For all solutions the arrangement entails only an agreement between the involved top stakeholders such as owner, main designer and main constructor. Subcontractors have specific contractual agreements as it is in traditionally organized projects. At least for private owners in Germany who want to

[4] Eschenbruch (2019)

initiate IPD- pilot projects it seems realistic to take one of the proposed solutions. The situation for public procurement is more complicated, because it is usually bound to the separation of procurement of services and goods and has to be studied additionally. For other countries this might be also a route to take: to look up which traditional elements of contracts can be applied and to go first steps by trying out aspects of IPD.

3.4 Integrating IPD in the BEP

As the BEP is a key document describing how the parties will work together, it will also be very important for any projects making use of IPD aspects. Compared to non-IPD projects the structure of a BEP will stay the same because the main purpose of the document remains.

What has to change is the level of detail in which certain points are described as there is a need for more explicitness. IPD demands a different kind of working together and sharing expertise. Therefore, the chapter on parties, roles and responsibilities has to be defined very carefully. For example, the parties have to work out explicitly how it is ensured that everyone has all information at all time. Also, one has to think of all details, e.g. which model template to use (if companies have individual templates) and how to meet the needs of all partners for the model, protocols for data losses, one standard package of software, etc.

As a first step for the use of IPD methods, the BEP can be created with all partners together (eventually one lead party should be appointed). This can also be oriented along the configuration of the IPD agreement. With respect to creating a BEP there are three different combinations possible: a joint venture, an applicant with subcontractors or applicants submitting individually with reference to partners. Regarding public procurement there may be some hurdles using IPD and thus describing it in a BEP. It stays a (legal) question how to procure services and good with only one tender process. Not every IPD constellation as described above is suitable due to legal constraints. Nevertheless, detailing any use of IPD aspects within a BEP – even only during a specific phase such as planning or carrying out – is always beneficially for the project and its participants. Agreements with the client are made easier and also amongst the different parties. Apart from this, it is also beneficial that once IPD methods are detailed in a BEP it is the contractor's obligation to yield to these conditions.

4. Procurement

The following chapter contains excerpts from chapters that originate from preliminary work made by PB40 in deliverable 5.4 "Guidelines for BIM-based procurement, collaboration protocols and IPD for renovation projects."

Using BIM methodologies requires a new manner of documenting the processes and services. When applied correctly, collaboration between interdisciplinary teams and an efficient project execution must be secured. Within any BIM-based procurement the documents Exchange Information Requirements, BIM Execution Plan and BIM protocol (or addendum) are essential as they contain specifications for the application of the BIM method. They supplement the contractual provisions for the execution of planning services with BIM and are henceforth addressed as *BIM collaboration protocols.*

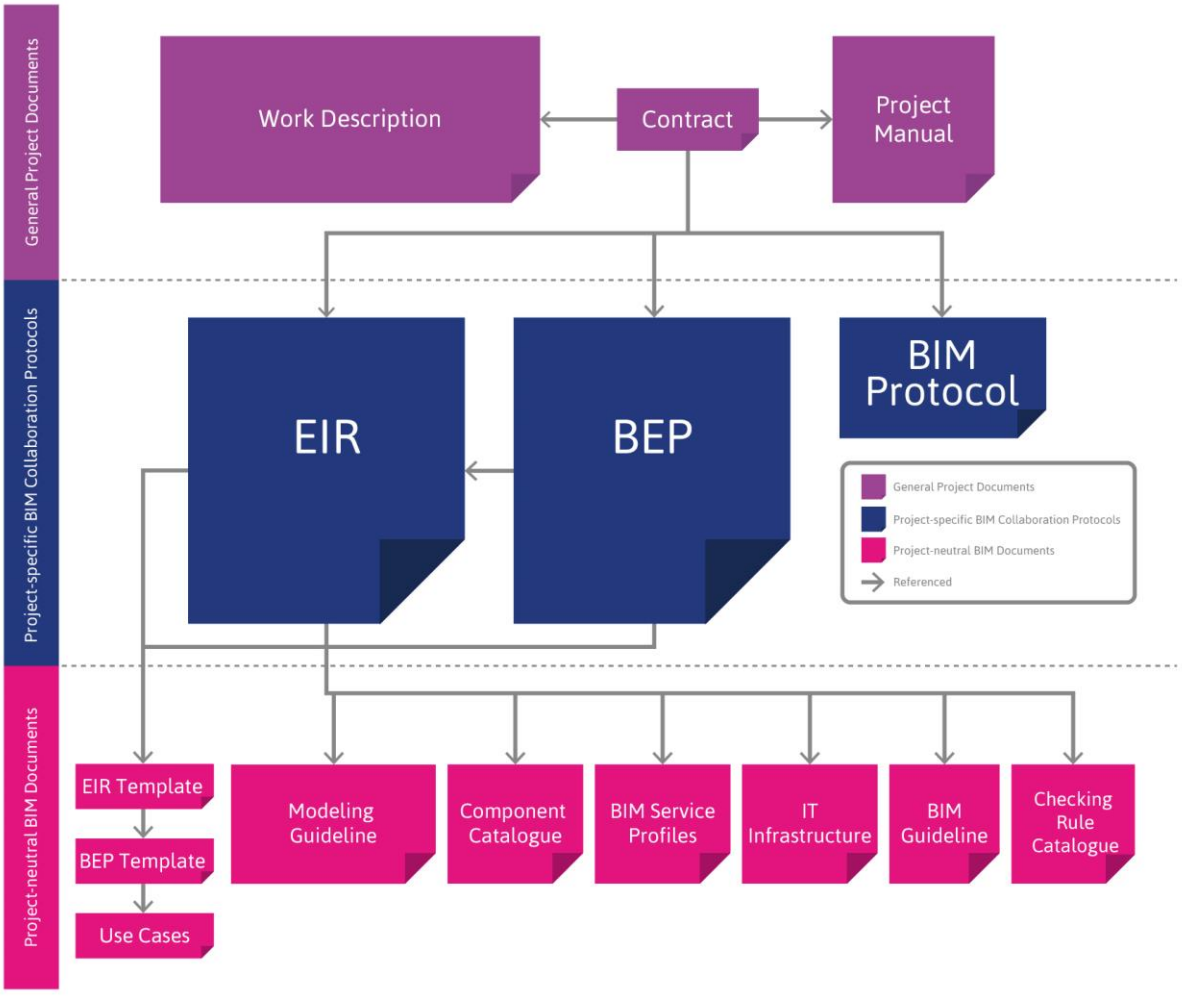

Figure 3: Overview project documents (Source: PB40)

Figure 3 provides an overview of the different documents together with other general project documents (contract, work description, project manual), project-specific BIM collaboration protocols (EIR, BEP, BIM protocol) and project-neutral BIM documents (templates for: e.g. EIR, BEP, use cases, etc.). These

documents – and especially the project-specific ones – can have various positions in the hierarchy of contractual documents depending on project and stakeholder.

In general, the EIR defines what must be delivered whereas the BEP defines how this is delivered. A BIM protocol can be used to set BEP and EIR into a legal order and protocol liabilities. Bearing in mind the main goal of this document – an effective coordination and collaboration between the different parties involved in a renovation project – the following chapters focus on the main document of collaboration, the BEP.

4.1 BEP in the Tender Phase

The separation of EIR and BEP according to the structure described above allows these documents to be used in different forms in award processes. The greatest distinction between these forms lies in the decision on whether the BEP is subject of the contract. Employers must decide according to their own affinity for risk and their own available resources to what extent they would like to become involved in data exchange processes themselves and make detailed specifications in this respect.

Figure 4 shows possible EIR and BEP combinations in the award process. In the following, they are explained and their pros and cons according to BIM4INFRA (2019) are presented.

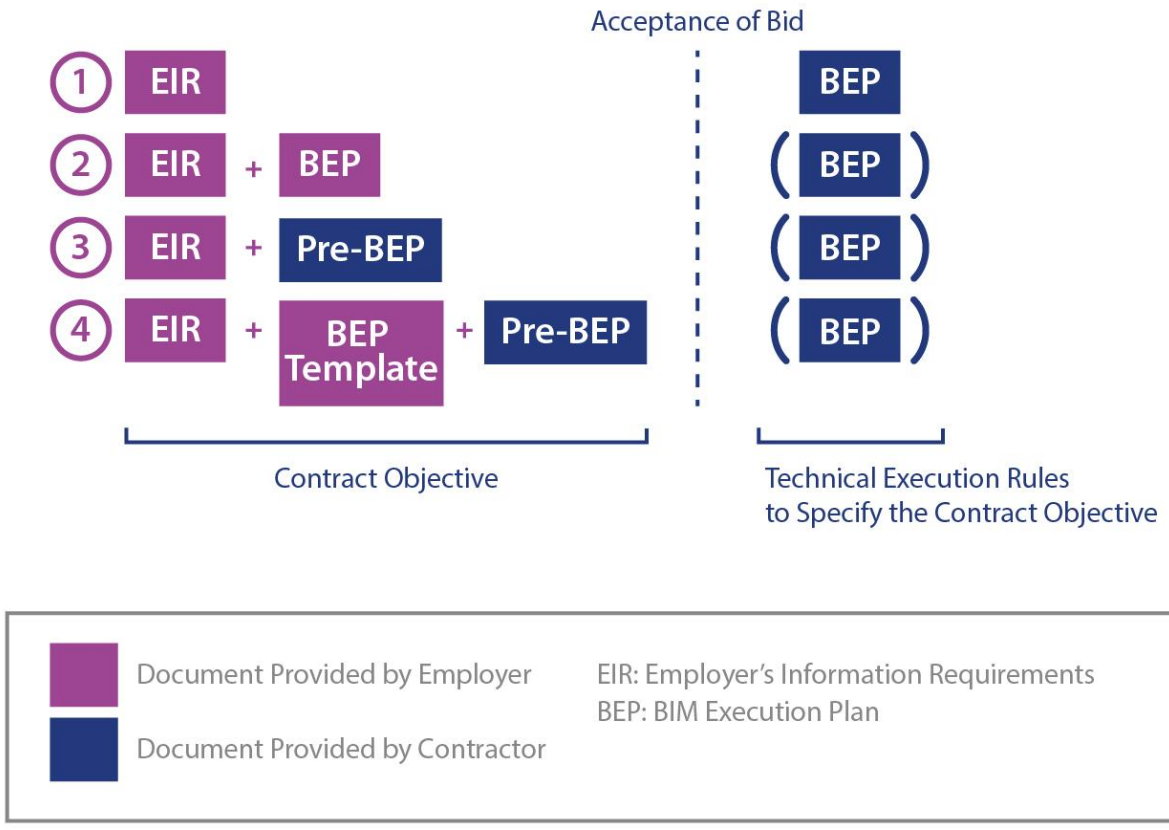

Figure 4 Different constellations for EIR and BEP (Source: BIM4INFRA (2019)

- **Variant 1:** In addition to the usual contractual bases, the contracting authority only specifies the EIR in the tender and no BEP. After commissioning, the contractors are obliged to develop

a BEP in coordination with the other project participants in order to document specifications on planned cooperation for the implementation of the EIR.

  - Pro: Employers are able to define their EIR, but do not consistently find themselves in a position to define a BEP.
  - Con: It is often impractical for the client if the parties involved in the planning process do not have to agree on how to produce digital work results until after they have been commissioned.

- **Variant 2:** In addition to the EIR, the employer prepares a BEP that specifies all details of the subsequent BIM processing.
  - Pro: If desired, the employer can be in full control of how the clients achieve the digital work results.
  - Con: This is a difficult task for employers and may not be feasible due to today's level of experience. Also, it may not be sensible for reasons of efficiency and liability because the project may become too bureaucratic and contributing partners can not involve their experience and special skills of BIM.
- **Variant 3:** The employer specifies the EIR and requires the bidders to submit a preliminary version of a BEP (a pre-BEP) in the award procedure, in which the bidders describe their implementation concepts for the fulfilment of the EIR. The pre-BEP is further detailed by the contractors into a BEP after commissioning.
  - Pro: A pre-BEP can be used as quality criteria in the award process.
  - Con: More workload is being added to bidders which might make the tender less attractive.
- **Variant 4:** The employer specifies the EIR and requires the bidders to submit a pre-BEP during the award procedure, but simultaneously provides a BEP template which is to be completed by the bidders. The pre-BEP is further detailed by the contractors into a BEP after commissioning.
  - Pro: Compared to variant 3, a more uniform implementation of the employer's concepts is ensured and the employer's expectations regarding the depth of content of the pre-BAP are communicated more clearly
  - Con: More workload is being added to bidders which might make the tender less attractive.

4.2 Creating the Pre-Contract BEP

In practice, it is always advisable to define a BEP which is why nowadays there is rarely a project without it. Without a BEP, the project is not effective because it is not secured that the services demanded in the EIR are going to be delivered. If for example, the client demands a data platform for sharing data and there is no agreement between client and employer set out in the BEP, the contractor can choose any simple data sharing platform which does not meet the expectations of the client, e.g. regarding 3D visualisation. Therefore it is crucial to set these details within the BEP.

Practice has shown, that from the previously described constellations variant 4 is going to be the most used one because of its advantages regarding risks. In this variant, the bidder can contribute his

competencies and does not have to put in the effort to create an entire BEP by him or herself. The client has a more uniform approach and thus a better comparability.

When creating a BEP template for the tender phase, the client should not set too many requirements. Therefore, the client has to know his or her needs and based upon this is able to create BIM requirements. In addition, these requirements have to be adapted to the skills of bidders but also of the client. Certain aspects have to be defined individually depending on the project, the client and the bidder, for example: LOD, CDE, native vs open files, scanning techniques, delivery of point clouds, BCF, platform for coordination of issues. In this sense, it is useful to formulate these aspects as concrete as possible – of course under the premise that concrete expectations from the client exist. This means in detail that the client necessarily has to develop the use cases as well as BIM goals making the use cases apprehensible. These are usually documented in the EIR. The BEP then gives answers on how to deliver these services. For example, it is usual that the client has expectations regarding data sharing and the contractor provides a CDE meeting these expectations. Regarding the topic native vs open files, a client can demand open files and the contractor delivers these at the data drops, but it can be useful to have native files as backup or for internal communication among contractors.

Once the bid has been accepted and the contract drafted, a post contract BEP defines in more detail the delivery of services. The only difference between pre and post contract BEP lies in its level of detail. Usually, the post contract BEP has more detailed specifications and is an expansion of the pre contract BEP. This implies that no information from the pre contract BEP is left out. If however, circumstances arise in which it becomes clear that certain information is wrong or unnecessary it is of course acceptable to delete these passages. More detailed information on the contents of BEPs, both pre and post contract, is described in the following section of this document.

5. Operational coordination and BEP structure

The previous section focuses on the procurement aspects of BEPs, including the pre-contract version of the document. There are many overlaps between a pre and post-contract BEP and thus this section will describe the document in general terms and any differences between the documents will be discussed. A key difference between them is that the pre-contract BEP is a response to the requirements set out by an employer, where bidders present their capability to meet the employer's expectations, while a post-contract BEP is typically a binding document outlining specific details as to how the contractor will fulfill their obligations including the master and task information delivery plans.

A properly constructed BIM Execution Plan will give a project and its participant a framework to be able to implement and achieve their desired goals and fulfil the obligations set out by the employer in the EIR. Projects with well-prepared BEP's have yielded quality results and streamlined work processes and collaboration. A BEP will allow each party to understand their roles and obligations, and allow them to assess their strength and weaknesses so that they will be better able to implement BIM as well as account for any needed training or other requirements. Overall a well-designed BEP will reduce unknowns and therefore risks associated with a project.

Along with information concerning the document itself and its structure, operational coordination between design and construction actors will be described within the framework of a BEP, to provide a clearer understanding of the functions each section of the BEP performs and the effect it has on a project's execution.

5.1 Assessment and Need

At the onset of the project, it is vital to assess the needs of the project and to decide to what extent BIM should be implemented in order to maximize the value that it will bring to that project. This could be done by the employer, who has created an EIR at an earlier stage, or possibly between a contractor and subcontractors. These needs, or BIM goals are project-specific, measurable, and could be applied to all stages of the project, from planning to execution and facility operation, if applicable. General goals may include an improvement to quality and performance, reducing costs, or reducing project duration. Other categories may include communication and collaboration, collision reduction, or energy efficiency improvement, all important in the context of a complex renovation project. These goals can also encompass indirect aspects of a project such as limiting its impact on the health and safety of workers and minimizing the disturbances experienced by residents or users of a building. Establishing them at the start of the project provides participants with an incentive to implement targeted BIM solutions within the project.

In order to achieve these goals, BIM uses, which are methods of applying BIM throughout the project, should be specified for each goal. BIM goals are not limited in scope to a single BIM use, multiple BIM uses may be used to accomplish the same goal. For example, if the goal is to increase project

speed during the design phase, some potential BIM uses may include using point clouds to model the existing state of a building, project coordination using a common BIM model, and automatic clash detection. Each BIM use should be described and have the parties responsible for its implementation assigned to it. Table 2 shows a set of example list BIM uses that can apply to various project stages according to the BIM Project Execution Planning Guide from Penn State University. This list is not exhaustive, and BIM uses should be considered based on the needs of each specific project.

Set of example BIM uses for various project stages	
Monitor System Performance	Analyse Lighting Performance
Monitor Space Utilization	Analyse Structural Performance
Monitor Assets	Analyse Energy Performance
Monitor Maintenance	Author 4D Model
Compile Record Model	Author Cost Estimate
Layout Construction Work	Analyse Program Requirements
Fabricate Products	Author Design Model
Author Temporary Construction Systems Model	Capture Existing Conditions
Author Construction Site Logistics Model	Site Analysis
Draw Construction Documents	Engineering Analysis
Analyse Sustainability Performance	Code Validation
Review Design Model(s)	Disaster Planning
Coordinate Design Models	

Table 2 An example set of BIM uses according to the BIM Project Execution Planning Guide[5]

All this provides a foundation for the remainder of a BEP, as all elements ultimately revolve around the needs and goals established in this section. Other valuable elements to include as a best practice are definitions as well as standards, norms or other references used when creating a BEP. Having all this in place should keep a project focused and allow for each project participant to have a clear understanding of the project objective.

5.2 Management

A BEP should lay out the groundwork for managing a project based on ISO 19650 principles. Assigning roles and responsibilities essentially creates the management team that will oversee the implementation of the project. The norm provides general guidelines as to how this should be accomplished. A hierarchy of information flow is created, describing between who information is exchanged. Individual task teams cooperate with each other and deliver information to the lead appointed party. This party then inspects and filters this information, cooperating with the task teams to ensure that the information received by the appointing party is sufficient. This hierarchy can be extended further down the chain or altered based on project needs. Specific names and contact information of people involved should be assigned in this management section. The pre and post-BEPs will differ here in that a post-BEP will include the specific teams, such as subcontractors, responsible for major tasks.

[5] Messner et al. (2021)

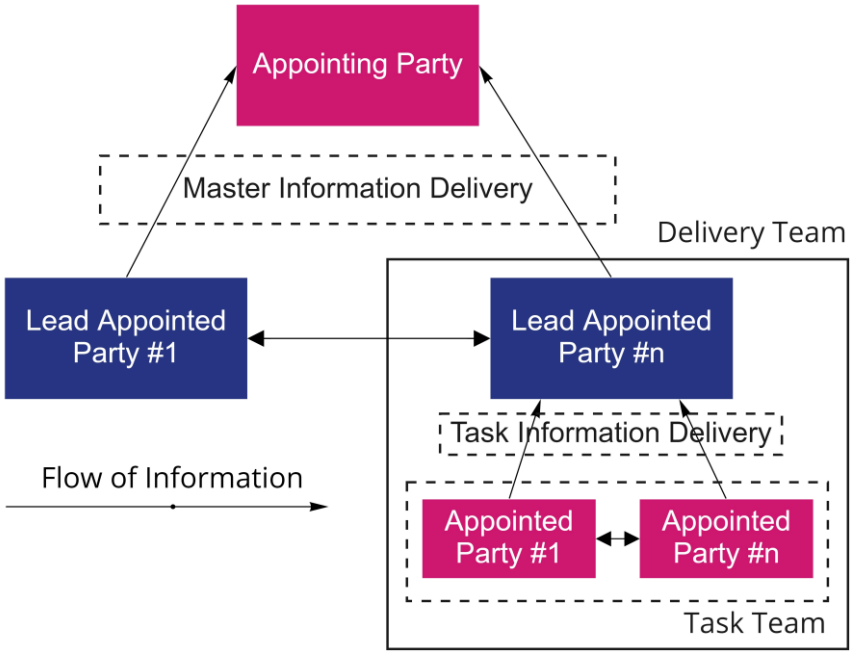

Figure 5 Diagram of the relationships between parties and information exchange between them

Major project milestones should be defined along with their expected date of completion. These can correspond to specific project stages for which BIM models should be created or updated. It is also possible for the management section to include information on the survey strategy for the given project, such as if traditional or LIDAR survey methods are to be used. Depending on the project and its needs, some survey strategies may be too intrusive for building users and others may not be adequate for the design needs, therefore it is necessary to determine this ahead of time. If the project is based on any pre-existing documentation, such as tender documents, they should be outlined in this section along with any file format that it may involve. This information must be included as relevant parties will need to be able to access any documentation on which the project will be based on and to ensure that contradictory sources are not used.

5.3 Planning and Documentation

A vital stage within a BIM Execution Plan is to include a blueprint of how the BIM process will be implemented across and within each team. This plan, which is usually developed post-tender once all project participants have been identified, encompasses the phases of mobilization and of testing methods and procedures, which are some of the early steps in operational coordination within a project. A strategy should be developed to assess each team's BIM capabilities, identify problem areas, and conduct necessary training sessions. An outline will be created to guide participants throughout a calibration and configuration process, allowing users to familiarize themselves with the procedures of working and communication outlined within the BEP. If it is realized that a team's capabilities are inadequate, then it is possible to account for additional training sessions or the need to add additional members to the team.

The CDE will be set up in this mobilization stage so that it is ready to handle the project's information exchange.

Additionally, it is important to consider the appointing party or, for example, building users through a housing association, and whether they will need to have access to the information, as they will need to be taught how to use relevant tools, software, or CDE as well. Periodic meetings pertaining to BIM implementation and issues may be coordinated in this section, such as a weekly coordination meeting where users analyse issues, clashes, and other technical issues that arise during the project.

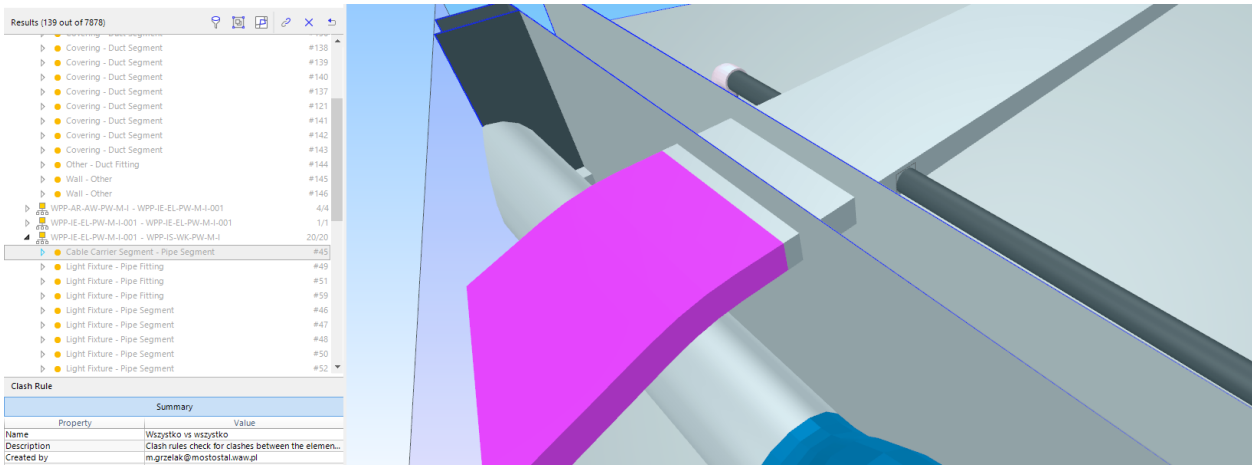

Figure 6 An example of the collaboration that may occur during periodic meetings - clash detection analysis in the Warsaw II demo

5.4 Standard Method and Procedure

A crucial element of a BIM Execution plan is the outline of the methods and procedures that are to be used during the BIM implementation and collaboration process. Risks should be identified and listed at this stage and mitigation strategies should be devised accordingly. A construction project has many unknown, and a renovation project even more so. It is important for project standards to be defined, such as classification systems, file naming convention, federation strategy, origin and orientation of models, tolerances, and units. Coordination becomes burdensome when participants do not adhere to these standards, as every time a model is received, it has to be reworked by the receiver, leading to lost productivity and time. There should also be requirements included regarding the level of information need. LOIN guidelines include both geometrical and metadata as well as contain a description of what constitutes each LOIN. Having it clearly defined will remove ambiguity, ensuring that all delivered models will be sufficiently detailed for the needs of the project. Note that different project stages may have different information requirements. A conceptual stage project will not need as much detail as a final as-built model, and as such should have less stringent requirements in order to avoid over-producing information and reducing the productivity of delivery teams. Each discipline should create a plan of action for preparing project components which will form a task information delivery plan. The plan should be composed of individual tasks along with assigned roles and dates of completion. The task information delivery plans from all disciplines, which are usually found in a post-contract BEP, will be incorporated into a master information delivery plan, which

outlines when information deliverables are due and who is responsible for them. These dates usually correspond to the milestones of the project and it is a good practice to spread out the deliverable due date and the milestone date to allow for time to review on the part of the appointing party and time for revision by the appointed party. This will reduce the possibility of delays when transitioning to the next project stage. In order to clarify the roles and responsibilities of each party, they may be presented using a responsibility matrix. At least one party will have the role of approving documentation. Acceptance or approval criteria and requirements for all project documentation need be clearly laid-out within a BEP. This table may need to be updated as new teams join the project after the contract is signed. A coordination process should also be devised that will ensure effective communication between parties, as well as organize the work-flow between them. Any standards or procedures that participating parties would like to have implemented during the course of a project should be agreed to and outlined at the onset of a project, while building the BEP.

5.5 IT Solutions

When working in a BIM environment it is necessary to decide what IT solutions are to be used during a given project within a BEP, otherwise costly software and technical problems may arise. If the project will make use of a Common Data Environment, then it should be specified in this section. As the name implies, this is a centralized data management tool that allows users in the project to upload and access project information in one location. This is essential to ensure that everyone is using the latest data as well as to keep it all organized. As part of the BIM-SPEED project, a platform was developed and used for many of the demonstration sites. The methods and procedures for the CDE should be defined as well as how access to the platform will be arranged. Other vital information to include is to identify software versions, exchange formats for sending and receiving files, as well as guidelines for ensuring data safety. Data safety must be ensured as there are a large amount of stakeholders that may be affected, including the intellectual property rights of designers and project owners as well as information regarding the users or residents of a building.

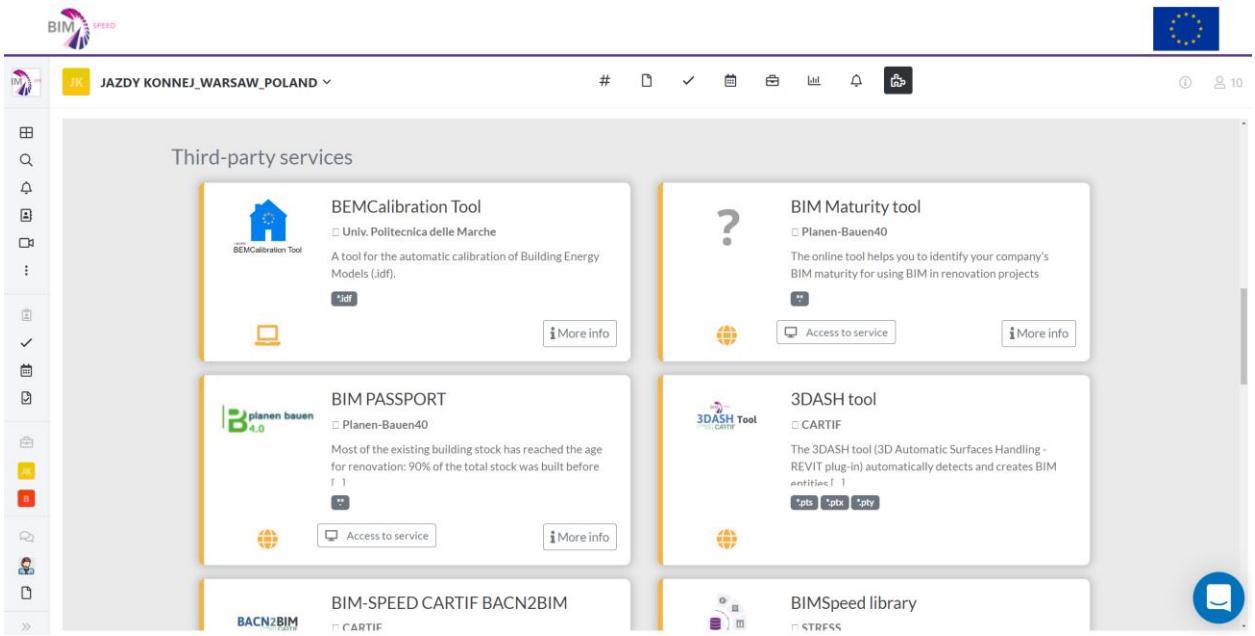

Figure 7 The BIM-SPEED Platform is an example of a CDE. It provides users with access to developed BIM-SPEED tools

5.6 IT Solutions in the scope of health, safety and environment

A CDE platform can also be used to aggregate information pertaining to health, safety, and environmental information affecting workers and residents. These platforms have shown to be a valuable addition during the construction process itself, where it can be possible to report health and safety issues or more broadly, any topic that may arise during construction or renovation. Many companies have been implementing these solutions as a replacement to more traditional forms of reporting. Without a CDE, a common procedure for reporting incidents would be to fill out forms manually, paste in any pictures, describe the location, and reach out to all parties which need to be informed. Later on, once the issue has been resolved, a confirmation must be sent again.

A CDE standardizes this workflow. It allows for needed information to reach the right people at the right time. The flow of information is controlled and set up at the beginning of a project. This includes who must receive information as well as who is responsible for accepting or making a decision. These issues or incidents can also be linked to a BIM model already on the platform for accurate location information as well as to provide a better overview of the situation. Having these issues on a digital platform allows for the easy collection and aggregation of data which can help to influence future decisions and outcomes.

The first use case for this is the reporting of health and safety violations in the workplace, which critically need to be resolved as soon as possible to ensure the safety of workers. This also helps alleviate the paperwork that comes with this process, as everything needs to be documented for liability or legal reasons. This, however, generally does not concern a project's investor, instead it is a useful tool to be used between a general contractor and its subcontractors. If, for example, there is a health or safety issue that involves the inhabitants of a building that is being renovated while residents are still living there, a CDE platform could be used to inform a housing association and allow for there to be a clear record

of events for the parties involved. The same goes for environmental issues that may affect different project stakeholders or for which the project's investor has a distinct interest in. Examples of these information flows may be seen in Figure 8.

In order for a CDE to operate in this space, information on its use must be included in a BEP, otherwise there is no requirement for parties to use the platform, therefore information cannot be exchanged properly. The aforementioned information flows are laid out in the BEP, including points on who is responsible for providing and receiving information. A BEP should also lay out which CDE platform will be used for HSE reporting and to what extent. Overall, a CDE can provide great bring benefits to a project, especially in terms of HSE management, but only if it is first defined in a project's BEP.

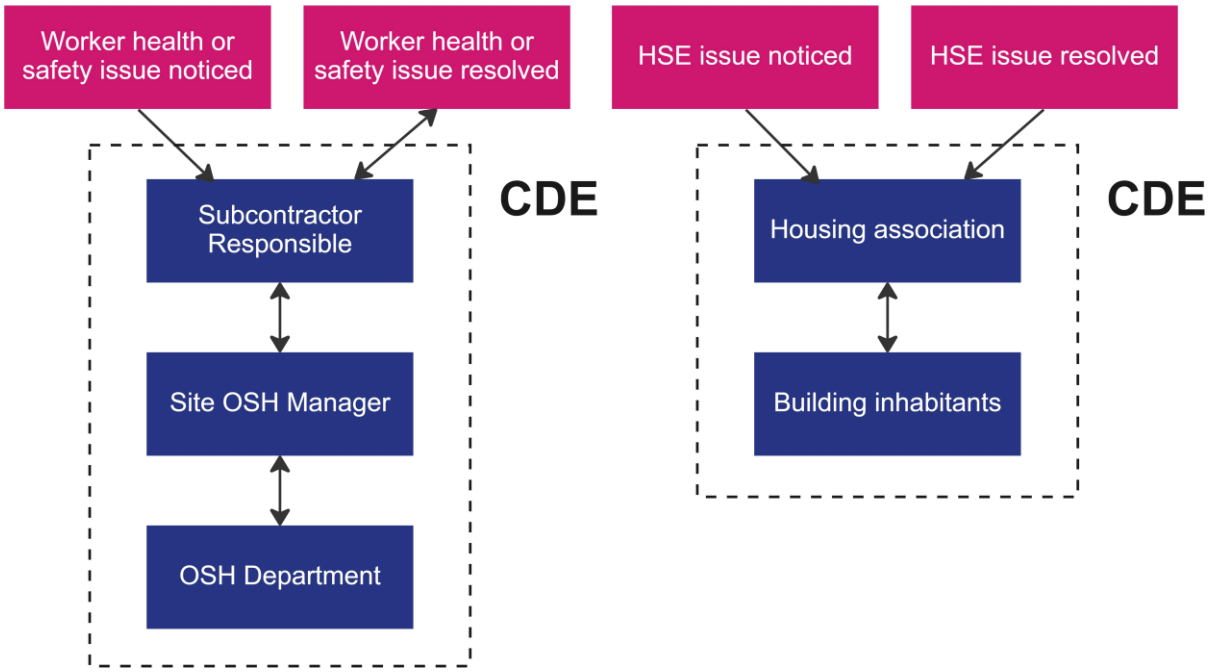

Figure 8 Potential information flows in a CDE

6. Conclusion

A BIM execution plan is an integral part of any BIM-based project. It has become a standard practice in the construction industry and this report has shown how it can also be implemented in a renovation project. A BIM execution plan should follow information management procedures laid out by the ISO standard 19650. Doing so gives interested parties a guideline for implementing a project efficiently and allow for the most optimal delegation of tasks. Along with information management, a BEP lays the groundwork for following integrated project delivery principles, as it allows for well-organized coordination between project participants.

This report has described the differences between how a BEP functions and its role in the procurement stage as well as the post-contractual stage of a project. The goal of this report was to describe BEPs and their implications generally but also to show how a BEP may be created for deep renovation projects. Therefore, BEPs were created based on BIM-SPEED demo site projects. Showing how BEPs may appear in actual projects will allow for a better understanding of how they are creating and hopefully make it easier to apply to future projects. The demo sites chosen for this task vary in function, scale, and complexity. This will provide future readers with the knowledge that a BEP is possible for their project, regardless of scale, and give different perspectives on how it can be accomplished. It is important to note that these BEPs were created for educational purposes, although some were based on real BEPs on projects already completed. Others were created based on the practical experiences and knowledge of the authors and made to replicate what a real BEP would have contained.

The report has provided the background and groundwork necessary for interested parties to be able to increase value in their projects using this BEP framework. Making use of the attached examples will enable the creation of future BEPs including those for renovation projects.

7. References

[1] Wright, J.A. (2012): The integration of building information modeling and integrated project delivery into the construction management curriculum. In 2012 ASEE Annual Conference & Exposition (pp. 25-1317)

[2] AIA Minnesota (2011). IPD Case Studies AIA, School of Architecture University of Minnesota February, 2011.

[3] Rowlinson, Steve (2016): Building information modelling, integrated project delivery and all that; in: Construction Innovation Vol. 17 No. 1 2017, pp. 45-49.

[4] Eschenbruch, K. (2019): Integrated Project Delivery aus der Sicht des deutschen Projektmanagements, in: Aktuelle Entwicklungen in Baubetrieb, Bauwirtschaft und Bauvertragsrecht, 2019.

[5] Messner, J., Anumba, C., Dubler, C., Goodman, S., Kasprzak, C., Kreider, R., Leicht, R., Saluja, C., and Zikic, N. (Under Development). BIM Project Execution Planning Guide, Version 3.0. Computer Integrated Construction Research Program, The Pennsylvania State University, University Park, PA, USA, Available at http://bim.psu.edu.

[6] BIM4INFRA (2019): Handreichungen, https://bim4infra.de/handreichungen/ (last viewed: 25.05.2022)

[7] Bolpagni, M., Hooper, E (2021): Information management according to BS EN ISO 19650: Guidance Part D Developing information requirements- Edition 2

[8] ISO 19650-1:2018

[9] ISO 19650-2:2018