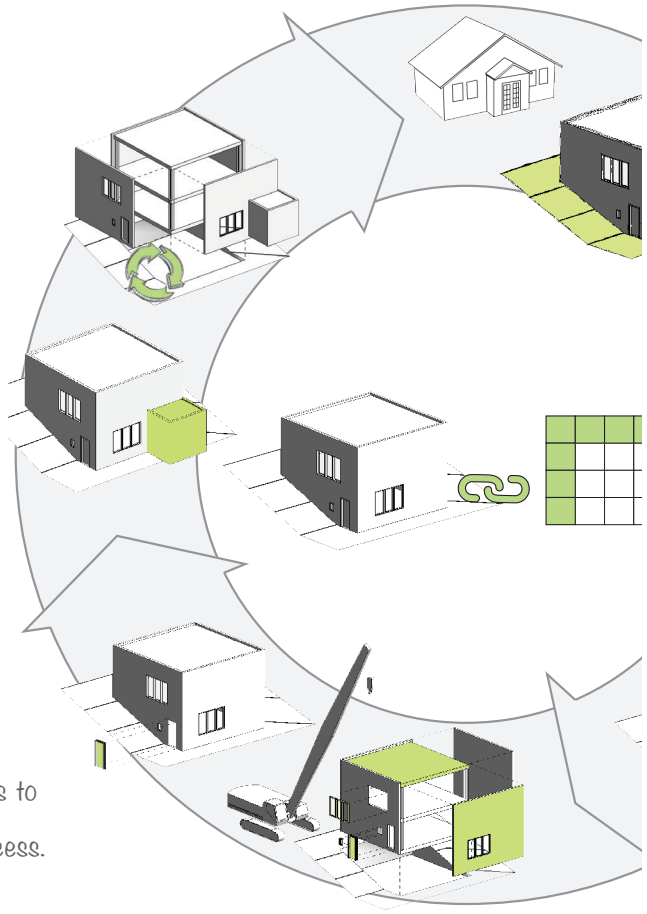
The guide to Building Information Modelling

BIM



This guide to BIM and its annexes present a "generic protocol" as well as general rules and fact sheets allowing the stakeholders to define the collaboration rules and thus, optimize the working process.

The better way to build

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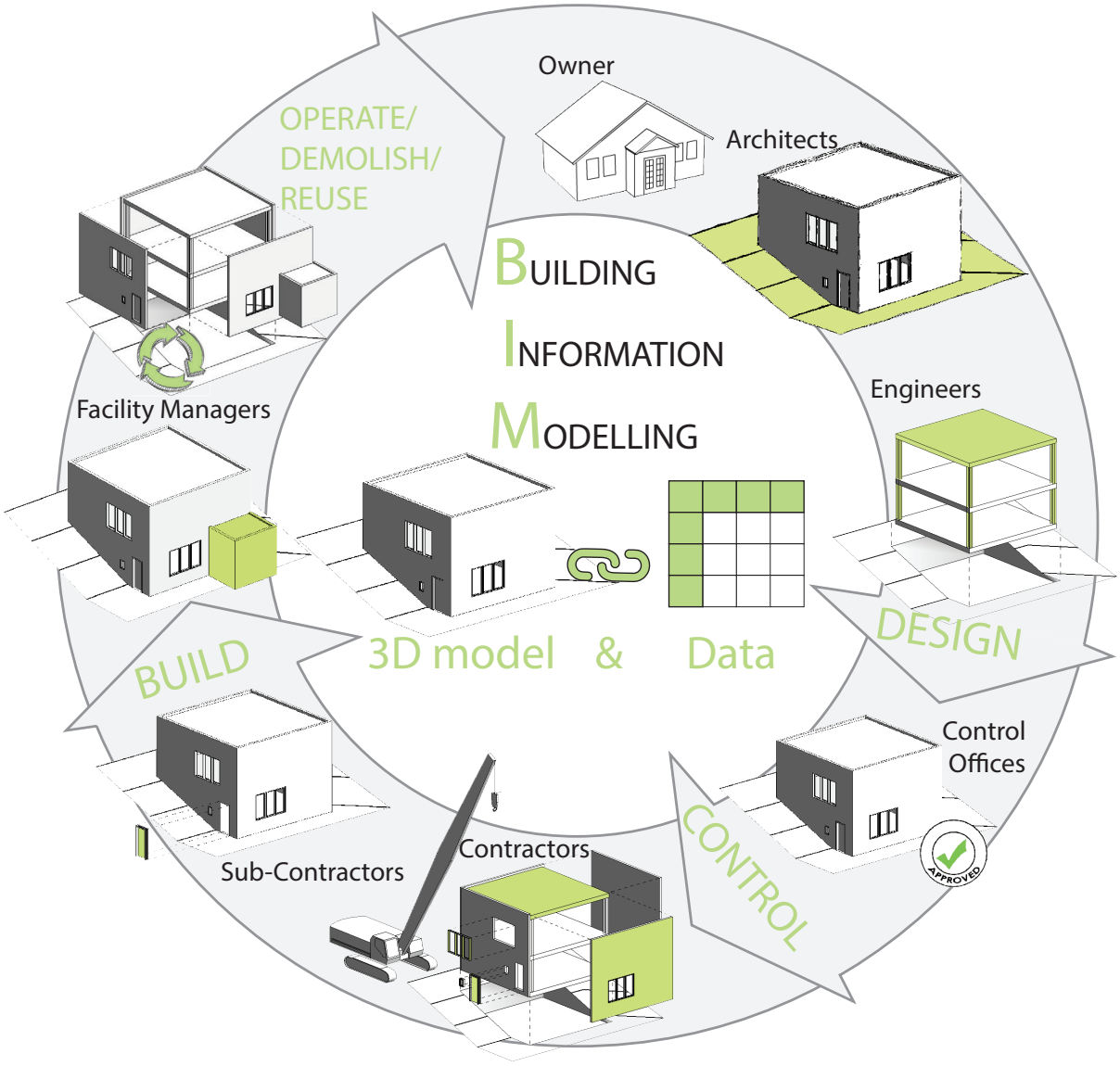
BUILDING INFORMATION MODELLING
BELGIAN GUIDE FOR THE CONSTRUCTION INDUSTRY



FOR OWNERS, ARCHITECTS, ENGINEERS, CONTRACTORS,
THIRD PARTY CONTROL OFFICES AND FACILITY MANAGERS

Figure 1: The building's lifecycle and its stakeholders (Denis, 2015)

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INTRODUCTION

The ADEB-VBA's (Association of major Belgian contractors) BIM work group, in collaboration with G30 (Association of Architects), ORI (professional organisation for engineering offices and consultancy), SECO as representative for Third Party Control Offices[1] and the Belgian chapter of IFMA (the international facility management association), is working on the improvement of collaboration and digital document exchanges between stakeholders of the Belgian construction industry.

To do so, the work group decided to focus on the classical contract (Design-Tender-Build) and define practical guidelines related to digital exchanges within this classical context. Indeed, the classical contract supports a segmented industry while other types of contracts involving all the stakeholders earlier in the process allow an easier BIM implementation. However, today, the classical contract remains the most common contract in Belgium. Therefore, the BIM work group, instead of separating the classical contract and a digital-collaborative process, decided to define rules and guidelines allowing the BIM use on a classical Design-Tender-Build process. As the classical process is the most segmented one and thus, the one with more stakeholders working with different tools at different times, a specific attention has to be made during the transitional phases (e.g. new stakeholders, new tools) and the transposition of these rules could be easily developed to other contracts by shifting agreements between the different stakeholders earlier.

This document and its annexes present a "generic protocol" as well as general rules and fact sheets allowing the stakeholders to define the collaboration rules and thus, optimize the working process. It should be stated that this document is supposed to evolve through feedback received from its use in practice. This document will be focused on three main topics:

- First, this document will provide information about BIM, its use and the specific roles/actors that have to be taken into account and incorporated in a BIM process.

- Second, general requirements related to BIM collaboration, document sharing and data management will be discussed.

- Third, a generic BIM protocol by phase and supported by a process map representing the traditional contract will help stakeholders to determine their project-specific BIM protocol.

Facility Managers are considered active stakeholders in the building life-cycle, hence, they are included in as active stakeholders in this handbook. This takes shape in two ways. First of all, at the end of the Design – Tender – Build process, the as-built information model should be decommissioned and handed over in an appropriate form to the facility manager, so that an improved building management can take place in the operational phase of the building (building use, building maintenance, rehabilitation assessment and design, demolition planning). Second, knowledge coming from the facility management domain (common practices, rules of thumb, common design errors) should find its way into the design – bid – build process via the appropriate BIM tools. The BIM handbook thus includes feedback mechanisms from facility managers into the BIM collaboration process from the very start of a project.

[1] Third Party Control Office : eng: third party inspection service; fr: bureau de contrôle technique; nl: technisch controlebureau

BIM GENERAL REQUIREMENTS

DEFINITION OF BIM

The term Building Information Modelling (BIM) has many interpretations and definitions. BIM is the acronym for Building Information Modelling or Building Information Model became over time Building Information Management. The different meanings of the same acronym is due to the fact that the applications of BIM have evolved over time and that the potential of BIM was wider than initially foreseen.

In general, BIM is defined at two different scales. In this BIM handbook, we will typically refer to the first definition:

- BIM is a process in which different actors work together, efficiently exchange information (data and geometry) and collaborate to provide a more efficient construction process (e.g. less errors, faster construction) but also more efficient buildings that produce less waste and are cheaper but also easier to operate. With that vision the key is not the three-dimensional modelling itself but the information developed, managed and shared, in support of better collaboration.

- BIM can also be seen as a software platform allowing to coordinate or combine the work of different stakeholders into one Building Information Model. A Building Information Model, is a three dimensional (3D) object-oriented model with embedded information. It means that it is a three dimensional representation of the building in which all the elements that compose the buildings are considered as "objects" connected to each other. Each object has a unique identifier and relates information about its geometry and its properties. This object oriented approach allows to organize the virtual model and develop different behaviours or interactions according to the type of objects (for instance, windows have special relationships with walls, objects can be attached to floors, walls, ceilings or other objects). In addition to those relationships, an object oriented approach also allows to store information by objects. Therefore, each virtual object with its embedded information can be easily used to define and identify the real element built on-site.

ADDED VALUE OF BIM

Building Information Modelling is generally used during design, construction and operation in order to:

- Provide support for the project's decision making process
- Parties have a clear understanding of the project objectives & interfaces with other related trades/stakeholders
- Visualize design solutions
- Assist in design and the coordination of designs
- Increase and secure the quality of the building process and the final product
- Make the process during construction more effective and efficient
- Improve safety during construction and throughout the building's lifecycle
- Support the cost and lifecycle analysis of the project
- Support the transfer of project data into data management software during operation

In order to reach those goals, the stakeholders have to collaborate and work together with the same aim, but also the same methodology and the same structure. Aim, methodology and structure are agreed upon among project partners. This procedure can be supported by a "generic protocol" and practical guidelines, which allow stakeholders to define the "rules of the BIM collaboration process".

BIM FUNCTIONS

Since the BIM process concerns the development of the virtual prototype of the building, but also the exchange and integration of information, there is a need to define new roles and responsibilities related to this process.

However, those new roles do not replace classical responsibilities and duties. Even if the BIM (model) is used to calculate cost there is still a need for a Cost Estimation manager. Thus, this document proposes an approach where the BIM roles/functions are defined as a support to classical functions. It should be noted that the term role does not mean person. Indeed, one person can have different roles or responsibilities.

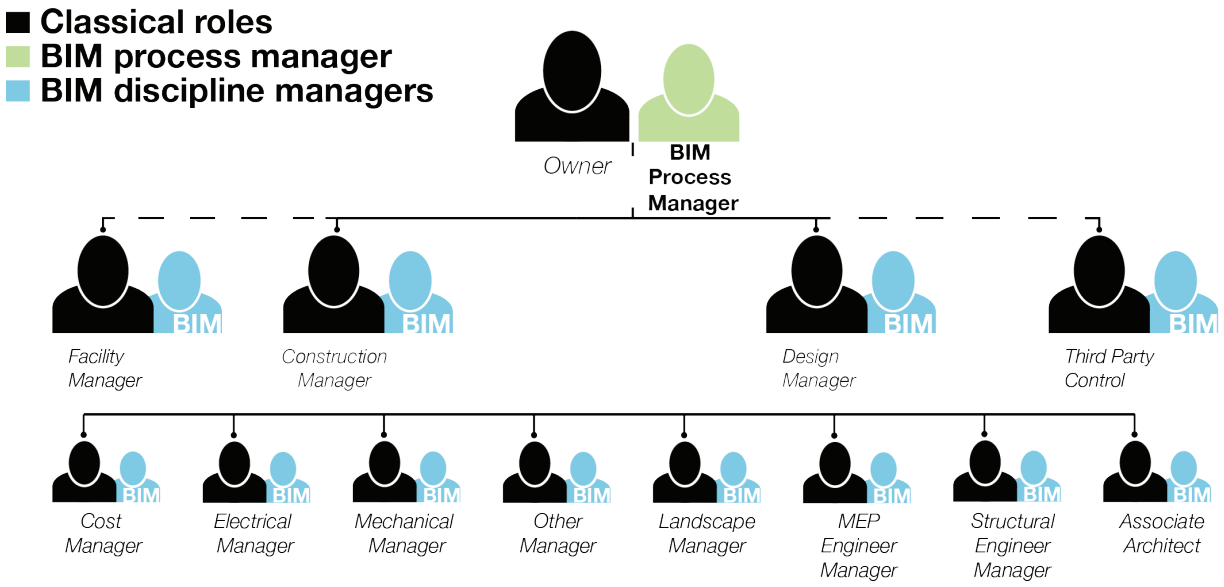


Figure 2: Each classical role (black) of project management is supported by a BIM role (green and blue) (Denis, 2015)

1. BIM PROCESS MANAGER

When a BIM project is initiated, there is a need to select a person responsible for specifying the project's BIM objectives and requirements but also for collecting and managing the data for the BIM work. In the traditional relationship between owner, architect and contractor in a building project, this person can be the architect. This function could also be accomplished by an independent party working for the owner in order to guarantee neutrality between stakeholders. However, the role of the BIM process manager can also be fulfilled by another party such as the project manager or the chief designer.

The role of the BIM process manager is to define the rules that have to be observed during the whole construction process, from the planning until the operation. He has to ensure that the information exchanged between the different stakeholders corresponds to the

rules fixed by the contract in terms of:

- Content (amount of information, maturity of information).
- Form (file format, e-mail or online service, presence of an exchange report).
- Timing (to keep watch on the timeliness of the BIM tasks are in accordance with the project planning).
- Ownership, privacy and security regulations.

Concerned with effective data exchanges, the BIM process manager is also in charge of:

- Determining the different development's stages of the model in parallel to the development of the design process (depending on the aim of the BIM)
- Determining with the stakeholders the frequency of models' update and coordination
- Determining the exchange process taking into account the software products used by the stakeholders.
- Informing the different stakeholders about the needs and requirements of the other parties
- Organizing coordination meetings between the different stakeholders to allow an efficient resolution of design issues (clash detection, generated reports, etc.).
- Testing and optimizing collaboration and information exchange in order to avoid loss of information.

The details of this BIM coordination process are described by the BIM process manager in a **project-specific BIM protocol.**

In order for the BIM process manager to properly accomplish all these tasks, it is desirable that he has experience in the field and in the software. It allows him to understand the requirements of the stakeholders that are seldom present at an early stage of the project (contractors, subcontractors, facility managers) and guarantee a smooth transition between all project phases.

2. BIM DISCIPLINE MANAGER

In addition to the BIM process manager who oversees, as described above, the data exchange process at the scale of the project, each stakeholder appoints at least one BIM discipline manager by discipline. This person is the direct link between the BIM process manager and the stakeholder. He is an expert in information management, modelling and specific company software. Furthermore, he knows what he needs to receive from the other stakeholders in order to deliver what is required and agreed upon in the project-specific BIM protocol.

3. BIM AND THIRD PARTY CONTROL OFFICES[2]

Generally speaking, the aim of the services provided by a third party control office is to contribute to normalizing technical risks by identifying potential sources of damage in the course of the design and execution phase of a project.

To do so, a meaningful part of the activities of a third party control office consists of consulting and checking documents that form the image of what will be constructed: sketches, architectural drawings, schemes, notes, computation models, construction drawings, …

[2] The intervention of a third party control office is voluntary, but becomes mandatory if one wishes to underwrite e.g. a decennial insurance policy covering the liabilities of the different building partners.

BIM GENERAL REQUIREMENTS

As non-quality issues can find their origin in every stage of the design course, it can be profitable to integrate the third party control office in the data flow procedures not only for exchange of final documents but also for interim exchange. That way potential problems can be anticipated in an early stage of the project and full advantage can be taken of the application of BIM-methodology.

With regard to document exchange, following recommendations apply:

- being neither a designer nor a contractor, and therefore not being allowed to alter a design, a read-only access to documents will generally suffice;
- however, when a document exchange platform is used, facilities for highlighting or making annotations are useful;
- if formal approval of a document is required, it has to be "frozen", which means that following elements have to be fixed: author, date, version, modifications compared to former version;
- document exchange with the third party control office is treated in the BIM execution plan;
- rules with respect to production of execution drawings used in factory or on site, are described in the BIM execution plan as well;
- the issue of archiving documents not only for the duration of the design and construction phase but also in the long run, has to be handled.

BIM RESPONSIBILITIES AND ADJUSTEMENTS

1. RESPONSIBILITY

Obviously, the traditional stakeholder's responsibilities remain in place. In addition, there is a need to define the BIM-related specific responsibilities. The common principle is to consider that the author of a model (part of a model) is responsible for its content.

In order to clarify to what extend we could rely on the model, a descriptive document has to be attached, updated and transferred with the model. This document is called the "Model Identification and Information Data sheet" presented later in the next chapter.

The BIM-related responsibilities and liabilities are specifically defined and fixed by contract between the different stakeholders during the elaboration of the BIM protocol.

2. FINANCIAL PLANNING

In addition to the changes in processes, roles and responsibilities, the usage of a BIM process also induces changes in the repartition of workload. More efforts are made in the early design stages, but, on the other hand, the time needed to produce documents is shortened. Therefore, the use of BIM induces an adjustment of the financial planning.

3. QUALITY

At least, the same level of quality as for classical documents has to be applied to the model and the digital documents. Quality control and validation processes have to be clearly defined within the project specific BIM protocol.

4. SECURITY

The same level of security as for classical documents has to be applied to the model and the digital documents. The access can be controlled using an "access code". It is also possible to enable different kinds of access such as "view only" access. The limitations concerning the access and protection of information have to be stated in the contract.

GENERAL RULES ABOUT BIM COLLABORATION

As the core of BIM is not the geometry itself but rather more the information attached to it, the key of a successful BIM process resides in the way we deal with information. Who produces it? When is it produced? What is the aim of the information? What about the limitations or inaccuracies? How is it shared or exchanged?

The key of collaboration is thus in the management of information. Information has to be produced, managed and combined in a defined and consistent manner (naming conventions, hierarchy, and classification). Furthermore, information has to be shared and the right data presented to the right people, at the right time using the right format. Since each stakeholder has different needs, different tools and different views on the project, he will probably need different information as well. However, the key of interoperability is to find a common language allowing to organize, classify, identify and share this information.

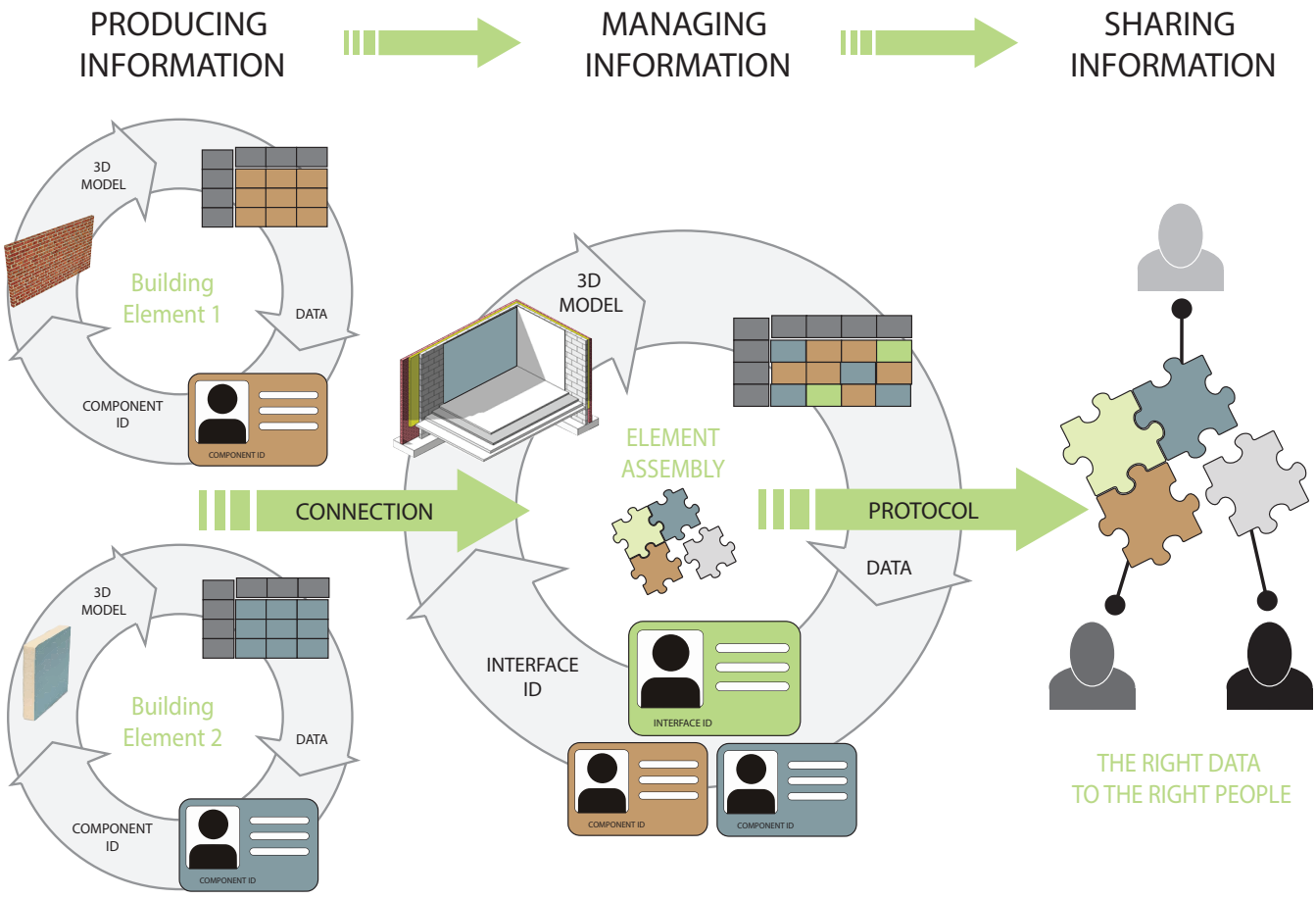


Figure 3: The key of BIM exchanges is the management of information (Denis, 2015)

Furthermore, the BIM (model) does not have to replace all the exchanged documents. Thus, the models do not need to contain everything from the environment to the reinforcements on a slab or the bolts on furniture as long as the limit of use of information and documents exchanged are well defined and correspond to the agreements signed by the stakeholders in the protocol (contract and protocol).

1. SOFTWARE PRODUCTS

Even if BIM is more a methodology than a software, it has to be applied using specific tools. As BIM is not only three-dimensional modelling, it requires specific tools that allow to produce geometry but also manage information. This is specially the case for software used by designers, because their work will be the core of the BIM process during construction. Indeed, they will model the building and its elements but also define their requirements or properties allowing contractors and other stakeholders to use the embedded information to buy, plan, assemble and construct the building.

However, some analysis tools do not require to be "fully BIM enabled" as long as they are able to import the needed information within the software (e.g.: tools that calculate thermal bridges). Obviously, the better the software is able to communicate easily (without import/export or manual operations), the faster the overall process will be, the lower the risk of errors or data loss.

2. PRACTICAL GUIDELINES

- **Use a reasonable level of accuracy:**

Since the building information model is the digital version of the building, the final version of the model has to correspond as much as possible to the **on-site** situation. It means that the final elements modelled within the software corresponds to real objects (e.g.: a column, a door, a window) or spatial concepts (e.g.: space, room).

However, the evolution of the modelling of elements has to follow the evolution of the design process. Indeed, there is no need to model elements too precisely at an early stage as long as the information stored in the model matches the needs at this stage (e.g.: conceptual geometries are sufficient at a pre-designed phase while model used for tendering is required to clearly define building components and construction methods). Therefore, all models from pre-design to as-built are made with the highest reasonable level of accuracy. Consequently, there is a need to define the level of information needed at each stage of the process as well as on the final model.

- **Use a common coordinate system:**

The coordinate system is determined in order to provide a common origin XYZ for all stakeholders. In order to avoid human errors (negative coordinates), the modelling area is defined within the XY positive area and the elevation Z is defined and documented. Furthermore, grids and levels are documented and defined using the same method.

- **Use of specific/pre-defined functionalities if they exist:**

Each element is modelled using as much standard software functionalities and object types (e.g.: walls, windows, doors, floors, roofs, components) as possible, provided they exist: If not, it is stated in a document attached to the BIM model.
e.g.: An element of the type "wall" is modelled using the wall creation functionality. If the standard tool is not able to produce the element (specific geometry), another functionality can be used but it has to be documented

- **Avoid clashes:**

Overlapping of spaces, elements or objects are avoided in order to avoid errors in quantity calculations or duplicates. Therefore, this has to be checked with clash detection procedures.

- **Inform others about the tools used:**

Each stakeholder provides a list of the software products used in order to allow improvements in the collaboration and digital document sharing through digital documents.

Similarly, information about the software used during design is part of the tender documents in order to allow contractors to determine the possible degree of interoperability.

- **Reduce the number of Export/Import Cycles and give priority to native or open formats:**

A process reducing the needs for export/import cycles will allow less information losses. However, even when using different software products, the information can easily be shared if well-structured and hierarchized.

- **Provide as much relevant information as possible:**

The more information is shared the more mistakes are avoided. A model is not useful without information about its limitations or the level of development of its content. A list of elements and their properties has no value if not linked to their location, their representation within the model or their identifier. Thus, the information can be in different locations, as long as it is defined, structured and linked (e.g.: naming conventions, linked files).

- **Change type of elements instead of deleting them:**

When changing an element (e.g.: wall) in a discipline model, the modeller is tempted to delete it and redraw it. This way of working does not seem problematic however, all the elements hosted by or attached to the wall/element will be orphaned. Each time an element is created, the software creates a unique ID for it. Any related element (e.g.: windows, doors) relies on that ID. If the element is deleted, the ID remains present in the project, but it is unclear to what it belongs to. In addition, data and links with other elements will be lost, whereas changing the element on place (e.g.: change element type) will keep everything updated and complete.

- **Model it as the contractor will build it**

Since the BIM (model) is a virtual representation of the real building, a practical approach is to consider it as a virtual prototype in which the stakeholders have to resolves issues as if they were working on the real one. Indeed, objects are modelled as they are constructed taking into account not only the final result but also the construction process (e.g. a column that is made floor-by-floor is different than a column made from the foundation to the roof). Furthermore, the model is managed as a "virtual construction site" where only one stakeholder is able to edit/create/change elements at a specific place. From this perspective, it is clear that a true collaboration and communication between the different stakeholders is needed to solve problems. Agreements making sure that the model is set up in correspondence with the needs and expectations of the different stakeholders (for instance, the manner of quantification) have to be part of the contract.

- **Use colour code (or identifier) per trade**

As it was stated before, the BIM (model) is a virtual prototype of the future building. Each element has to be modelled as it is constructed. However, the model has the advantage of allowing visual representations that are not necessary realistic. The use of colour (or identifier that can be filtered) to differentiate different trades is an efficient and practical way to identify different objects from different trades in a coordinated model.

- **Limit the number of model**

The BIM coordinator is required to coordinate all different BIM models that are made in the entire process by all BIM discipline managers (architectural, structural, MEP, HVAC). For this process to remain efficient, there is a need to define the right number of models. Too many models will increase the complexity of the coordination between the different models, while too few models will generate issues related to software and hardware capacity, interoperability and authoring. Therefore, the BIM process manager has to determine with the BIM discipline managers the right number of models that will be developed.

3. IDENTIFICATION OF CLASSIFICATION SYSTEM

In order to allow all stakeholders to organise objects using the same naming conventions, a classification system has to be chosen. This classification system also avoids errors due to the use of different languages to define different elements: *a door, een deur or une porte.*

There are at least 4 different approaches to classify objects within the building industry:

- Zone Classification – *geographical classification*
- Type Classification – *object based classification*
- Activity Classification – *field/discipline classification*
- Functionality Classification

Table 1: Non-exhaustive list of classification systems

Classification System:	Purpose:
Cuneco Classification System (CCS - www.cuneco.dk/English)	Digitally oriented Classification System developed in Denmark and supported by Open BIM
BB-SfB	Belgian adaptation of the Swedish SfB, widely used in Belgian construction industry
Uniclass 2	It is the new UK implementation of the international framework for construction information (ISO 12006-2)

The choice of a classification system depends on the needs of the projects (e.g..: building versus bridge). Therefore, the classification system can be developed specifically for the project or based on an international or standardised classification system as long as it is clearly defined at the starting of the project and fits the project needs.

Task for "Identification of Classification System":

- *Define objects and files naming conventions and classification system and document it in the document entitled "Naming Conventions"* **[Annex G]**

4. EXCHANGE PROCESS

The exchange process has to be clearly identified and described by the BIM process manager. The model with its description document is handed in at a specific time and following a specific method. Moreover, the reception and the acceptance of such a model by another stakeholder or by the BIM process manager has also to be clearly defined. The Process Map (Classical Contract) developed in the **[Annex A]** could be used as a basis to determine the main exchanges. However, the efficiency of a BIM process depends on the degree of collaboration between the different stakeholders, thus, the more interaction between parties, the more emulation could emerge. Hence, more exchanges are highly recommended, in the form of continuously ongoing exchanges of working models and documents. The exchanges schematised on the process map are only the key/main exchanges. Other smaller exchanges of working models/documents occur continually. A project specific process map that includes exchanges details per phase could also be developed based on the **[Annex A]** to support such custom additional exchanges.

4.1. File format

Concerning the file format used to work together and collaborate, a simple rule shall be followed:

- **Reducing the amount of imports and exports will always reduce the number of errors and the amount of unnecessary reworks, and increase the quality of the embedded information.**

Therefore, if two programs share a common native format it shoulbe chosen. If not, the BIM process manager is responsible for defining the file format that has to be used, in harmony with the concerned BIM discipline managers. The format will be chosen according to the type of information needed and the tools used by the different stakeholders. Thus, if a stakeholder only needs geometry, only a purely geometric 3D model will be sufficient, however, if a stakeholder needs geometry and information about specific components there will be a need to clearly define the needed information and thus, the exchange format.

Furthermore, one-way or two-way exchanges do not have the same limitations concerning file format. If a stakeholder only needs to access the model information, without editing it, in order to generate a report or an analysis, the chosen file format can "freeze" the project at a specific stage. Once the report or analysis has been made, it is the duty of the model authoring party to integrate/update the model with the results. In general, finding a common format for one-way exchanges is easier that for two-way exchanges.

However, if the structural engineer needs to change the location or orientation of a specific structure, he could need an editable-file. Thus, the receiving party modifies the model and has to share it to the original author of the model. Those two-way exchanges are more complex because of the lack of interoperability between software products. This is why they have to be implemented only when needed.

Another method using a hybrid-one-way exchange, is a process where the architect produces its own architectural model that is used as a support for the structural model made by the structural engineer. Each time, there is a need to update the structural model, the architect provides his architectural model and the structural engineer updates his own model and then shares it. This kind of process is based on one-way exchanges that are linked together and support collaboration. They have the advantages of being easier to develop than the two-way exchanges and less "rigid" than the one-way exchanges.

Taking into account this discussion of the link between the exchanges and the file format, the following practical rules will complement the one developed above in improving the workflow:

- **A distinction between one-way and two-way exchanges has to be made in order to optimize the collaborative process (if one needs to read the information a pdf/picture/3d model is sufficient but if one needs to edit it, an editable document is more convenient).**

- **If a "simple" one-way exchange is sufficient for a specific task, then do not implement a "complex" two-way exchange.**

- **There is no need to export a full model if a simple data sheet/document is able to store the information needed.**

Note about Industry Foundation Classes

The Industry Foundation Classes (IFC) file format is known as the international BIM exchange standard. Indeed, it is an open file format that allows a non-proprietary storage of BIM information. However, IFC is not an "only push the button" solution, it means that the IFC importation or exportation, as it was the case with PDF few years ago, requires a considerable number of settings to be set in order to be useful. Thus, even with IFC, the person who transmits the model must clearly determine what is exchanged, and check the information within the IFC file and comment it. Therefore, the IFC format, even although powerful, remains a non-native exchange format and the creation of such a file using a proprietary software (e.g.:Revit, Archicad, Tekla) is definitely not an "out-of-the-box-without-any-losses" feature. In other terms, the use of IFC does not avoid the need to clearly determine the exchanged documents and the exchange process.

4.2. Model content and levels of developments

The BIM process manager and all the stakeholders (e.g.: BIM discipline managers) must clearly define at each stage of the BIM process what content and what level of development they expect. The term "Level Of Development (LOD)" is commonly used to represent the level of precision of model content. This is the degree to which an element's geometry and its attached information have been thought through – the degree to which project team members may rely on the information when using the model.

Level Of Development (BIMforum, 2013; Moreau 2012)

LOD 100: Conceptual design

The objects have a geometrical representation using a symbol or a generic representation. The global model can be used for solar and early energy analysis.

LOD 200: Design Development

The objects have a geometrical representation using a generic system, object, or assembly. Approximated information related to quantities, size, shape, location and orientation are also determined. The global model can be used for general performance analysis and calculations.

LOD 300: General Construction documents

The objects have an accurate geometrical representation with a specific system, object or assembly. Information related to quantities, size, shape, location and orientation are also determined. The global model has enough information to provide precise analysis and simulations on every element and system. Furthermore, tasks related to collaboration, such as coordination and clash detections, can be performed.

LOD 350: The compromise

The objects have an accurate geometrical representation with a specific system, object or assembly. Information related to quantities, size, shape, location, orientation and interfaces with other building systems (= LOD300 + interfaces) are also determined. The global model is particularly suited for the use of the model to support the constructive process. It has the advantage of being easier to develop than the LOD400 but providing more useful information than LOD300.

LOD 400: Fabrication information

The objects have an accurate geometrical representation with a specific system, object or assembly. Information related to quantities, size, shape, location and orientation are with detailing, fabrication, assembly, and installation information. The global model can be used for direct production and construction scheduling.

LOD 500: As-built model

The objects are a field verified representation in terms of size, shape, location, quantity, and orientation. It is the As-Built version of the BIM. In these models, elements are represented with all technical information needed for maintenance and procurement.

As an additional remark, it should be stated that there is no exact correspondence between the LOD and the design or construction phases. Each building system is developed at a different speed during different phases. Therefore, the determination of the LOD describes the expected LOD for a specific building system at a specific stage. Similarly, there is no "LOD 350 Model" but a specific model (e.g.: Architectural, structural) in which different building systems are developed at different LODs.

The expected LOD by element/category/building system at each stage of the project has to be determined and documented.

In addition to that, the following elements are defined:

- What is modelled? What is not modelled?
- Additional comments on the level information that are missing in the LOD
- Specific conventions of the project (e.g.: spaces with an area > 3 m² are modelled or elements of dimensions < 1 cm are not modelled)

Task related to "Model content and levels of development":

- *Complete the document entitled: "Generic Exchange [Design/Construction] Level Of Development Requirements" in* **[Annex F]**

4.3. Updating models and documents

Each BIM discipline manager shall maintain a Model Identification and Information Data sheet (M.IDS) that defines and documents his discipline model. It has to contain at least:

M.IDS content:

- *Identification of the discipline*
- *Definition of the model's content and LOD*
- *Purpose of the model*
- *Information about the source document or model used to develop the model (e.g.: engineering offices models are based on architectural model), including the version of the source model, and a list of the reference drawings and technical notes used.*
- *Information on the modelling software*
- *List of exceptions to the defined requirements (handbook or contractual requirements)*
- *Information about the naming conventions used*
- *Version and most important changes*
- *Limitations concerning the use of the model*

An example of "Model Identification and Information Data sheets – Model.IDS/M.IDS" is available in **[Annex H]**

The M.IDS document is updated and published with the BIM model. A model without a "Model IDS" is not usable because it provides no information about its limitations, its use and its accuracy. Following the same principle, documents are also exchanged with an updated Document Information and Identification Data sheet (Document.IDS). This sheet contains at least:

D.IDS content:

- *Identification of the discipline*
- *Purpose of the document*
- *Limitations concerning the use of the document*
- *Version and most important changes*
- *Additional Information*

Each party is responsible for the consequences of incomplete or inaccurate documents taking into account: the contract and the limitations expressed in the model/exchange description documents.

4.4. Key exchange models and documents

The key exchange models and documents are the main documents that are exchanged or published during the key moments of the project. They have been identified and are represented by the numbered documents within the process map provided in **[Annex A]**.

Those documents are not only used to assess to what extent the different stakeholders respect their engagements, they are also used as

starting points for further works (e.g.: new model), improvements or are part of the official documentation of the project. Thus, those documents have to respect the rules agreed earlier in the project in terms of documentation and exchange requirements.

The content as well as the level of development of the components are defined earlier in the process by the BIM process manager and the BIM discipline managers and are secured by contractual commitments. Those documents are also frozen and archived at specific stages of the project to keep track of responsibilities during the project and of the overall evolution of the project.

Each bundle of key exchange models and documents has to be accompanied by an "eXchange Identification and Information Data sheet (X.IDS)" stating:

X.IDS content:

- *The exchange identification name*
- *Date of the authoring*
- *Version/ Revision*
- *The transmitter of the document*
- *The initiating BIM discipline manager*
- *The receiving BIM discipline manager*
- *Limit of use*
- *Content (description)*

*An example of "*Exchange Identification and Information Data sheets – eXchange.IDS / X.IDS" is available in **[Annex I]**. This document has to be completed for each exchange.

In addition to those identification data, the following information is stated:

- A document list that states:
  - *Name + Version of the document*
  - *Trade*
  - *File format*
  - *Author*
  - *Comments/Limitations in use/Exceptions to requirements for each document exchanged*

- BIM model checklist:
  - *M.IDS number, date and version*
  - *Checklist stating whether or not the BIM model corresponds to the requirements*
  - *Information concerning the model checking (manually or model checking software)*
  - *Additional comments*

Tasks while using the eXchange.IDS:

- *Complete/Update eXchange IDS*
- *Check exchanged documents and models taking into account:*
  - *Format*
  - *Content*
  - *Version*
  - *Requirements (Comparison between eXchange requirements and the actual result)*

4.5. Working models and documents

Working models and documents can be exchanged as well, in addition to the more official key exchange models and documents. They are used as intermediary documents and enhance the collaboration between two stakeholders in a direct collaborative workflow. The working documents exchanged can be less documented if it is agreed between the concerned stakeholders and the BIM process manager. Those direct exchanges also may concern a "subset" of specific information concerning an adaptation or an evolution of a part of the project, in contrast to key exchange models and documents, which present all the necessary documents to appreciate the project at a specific stage.

4.6. Models and documents reception acceptance

As each stakeholder is responsible for the model that he sets up, he also has to check if the models and documents he receives from the other parties to build his model with, meet the requirements that were agreed. With this in mind, the protocol has to provide information concerning the exchange process but also the acceptance of documents. This acceptance can be done using a checklist documenting the parts that respect or not the rules determined at an earlier stage.

The checklist that is part of the X.IDS has to be used to identify whether or not a model or a document corresponds to the requirements. This checklist is completed by the author and is then checked by the receivers allowing them to add comments or highlight issues.

5. COLLABORATION PLATFORM AND COMMOND DATA ENVIRONMENT

As BIM means collaboration and document sharing, the availability and accessibility of updated documents is a key issue. Sending documents by e-mails is not a solution in the context of thorough collaboration and document sharing because it generates issues related to doubles and revisions management.

There is therefore, a need to use a shared online platform. There are different kinds of collaboration platforms, ranging from the single server managed by one of the stakeholders to the specialised platforms developed by software developers or BIM consulting companies. As the collaboration platform is clearly linked to the BIM process, its selection and configuration is part of the BIM process manager's and the BIM discipline managers' duties.

In terms of functionality, a platform has to:

- *Allow an organised files storage (e.g. tree structure)*
- *Allow multi-user and multi-location access to the models and documents.*
- *Allow manage of files' ownership, authoring and responsibility (save logs; trace author, readers, modifiers)*
- *Allow a unique, chronological and non-redundant information exchange channel (ban duplicates, store a frozen version of the model at defined stages)*
- *Allow users to work on the last updated document (versions management)*
- *Allow an automatic creation and management of archives*
- *Allow user access management and secure authorisation*
- *Support approval workflow*

Other extra functionalities that have to be dealt with:

- *Legal functionalities, possibly by a trusted third party, requiring access and conservation of documents and models*
- *Advanced stakeholder management, including their responsibilities and rights*
- *Assembly of sub-models and online viewing of the coordinated model*
- *Free viewer mode*

It should be noted that the use of a collaboration platform in itself does not guarantee an efficient exchange of information. It is only a tool that allows document storage, management and exchange. A practical working process and a list of practical collaboration rules still have to be determined by the BIM coordinator and the BIM discipline managers.

For example, two very common practical rules that allow proper version management, are:

An actor does not alter the contribution of another actor
A document is exchanged/shared only if it is accurate and properly described

CONCLUSION

The first part of this document introduced the general concept of BIM and provided information about the general requirements or changes that are induced by the use of digital-and-collaborative exchanges. These practical guidelines came from a literature study as well as the experience of the members of the BIM work group and will be completed and evolve throughout the different version of this document.

Their use will enhance collaboration and communication between stakeholders allowing them to understand the needs of others as well as their duties and provide useful and reliable documents. However, these rules have to be determined at a specific stage of the process but also adapted to the specificity of each project. Therefore, the next part provides a "generic BIM protocol" allowing the BIM process manager to define clearly the collaboration rules but also, providing him information about the timing of these rules.

It should be stated that the aim of these guidelines is not to reduce the freedom of the different stakeholders but to allow them to exchange information reliably and efficiently. Indeed, the more people around the table the more solutions can be found:

"A knotty puzzle may hold a scientist up for a century, when it may be that a colleague has the solution already and is not even aware of the puzzle that it might solve."
– Isaac Asimov, The Robots of Dawn –

So, let's start exchanging, producing and communicating but first, we must define the collaboration rules and requirements by writing them down in a BIM protocol.

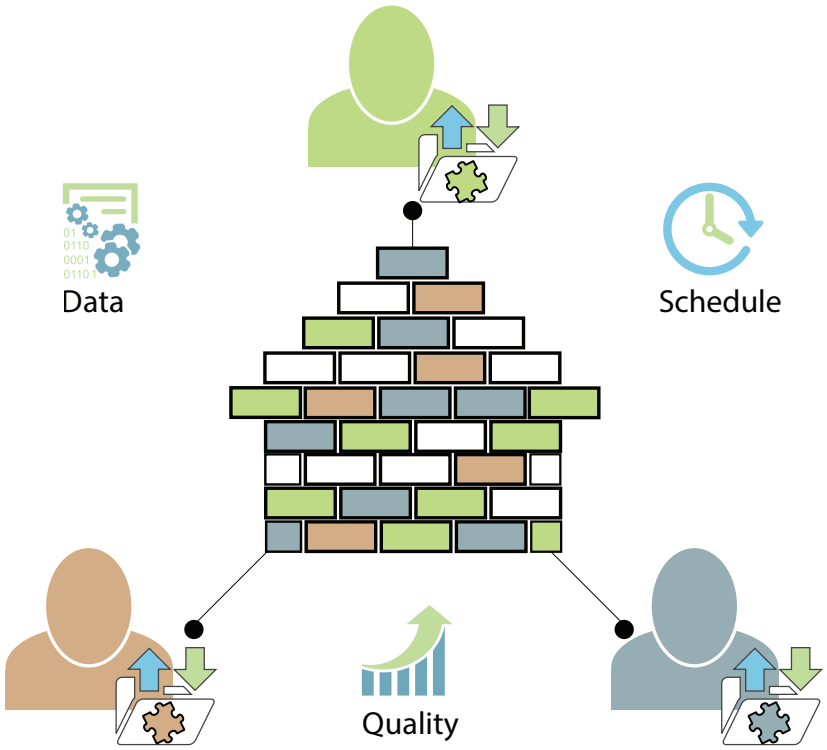


Figure 4: Stakeholders' collaboration managed through a BIM protocol will improve the completeness of information, the schedule management as well as the global quality of the project (Denis, 2015)

INTRODUCTION

This chapter will develop a generic BIM protocol used during a classical "Design-Tender-Build" contract, thereby relying on the requirements and context documented in the previous chapter. As a BIM process is mainly defined through its collaborative process, there is a need to define guidelines allowing collaboration, document sharing, and model sharing between stakeholders during the project.

The construction process of the classical Design-Tender-Build contract (actual situation) has been schematised in a process map. On this map, the key steps and exchanges are represented using numbers. This chapter will develop the needs for each step. Indeed, as the classical contract is segmented and requires the introduction of different stakeholders at different stages, a BIM protocol where everything is fixed at the beginning of the project is unpractical. Thus, this protocol proposes a process allowing to define several objectives at different stages of the process. The objectives and requirements are supposed to evolve throughout the project.

The practical rules provided in the previous section are valid during the whole process. However, some of them will be more detailed during specific stages. The tables defining the different exchanges are partial proposals of requirements based on the document "Generic Exchange [X.X] Model Use Requirements" **[Annex E]**. However, the full document has to be completed for each exchange.

In addition to this document, the level of development expected at each exchange should also be stated in "Generic Exchange [Design/Construction] Level Of Development Requirements" **[Annex F]**.

Finally, a grey table that summarises the main actions or documents, that have to be completed or developed by the BIM process manager, is provided at the end of each section. Theses tables could be completed and used as checklists.

PROJECT INITIATION / PRELIMINARY STUDIES

When starting a project using BIM the following recommendations shall be followed:

A. The owner appoints a BIM process manager who is responsible for defining the exchange rules and who supervises whether they are respected or not.

B. The owner, helped by the BIM process manager defines the aim and expected use of the Building Information Model:

- Determine the use of BIM and thus, define to what extend the model will be developed:

  - Support collaboration during design only (3D model and basic information).
  - Support collaboration during design and construction (design optimisation, 4D planning, cost management).
  - Support collaboration including operation (maintenance, facility management, demolition).

In (Kreider, Ralph G., and John I. Messner, 2013) the BIM uses are defined, explained and developed. This document could be used to determine how BIM will be used in a particular project. The BIM uses are divided into 5 main groups:

- Gather (Quality, Monitor, Capture, and Quantify): to collect or organize facility information.
- Generate (Prescribe, Size, and Arrange): to create or author information about the facility.
- Analyse (Coordinate, Validate, and Forecast): to examine elements of the facility to gain a better understanding of it.
- Communicate (Visualize, Draw, Transform, and Document): to present information about a facility in a method in which it can be shared or exchanged.
- Realize (Fabricate, Assemble, Control and Regulate): to make or control a physical element using facility information.

More detail about this classification of BIM uses is available in the full document:
Kreider, Ralph G. and Messner, John I. (2013). "*The Uses of BIM: Classifying and Selecting BIM Uses*". Version 0.9, September, The Pennsylvania State University, University Park, PA, USA. *http://bim.psu.edu.*

C. The BIM process manager facilitates accessibility to available site inventory/survey documents in order to optimise the use of already available information in the BIM process.

D. The owner appoints the design team (Architect, Engineering offices, Facility Manager).

Task of the BIM process manager:

- Definition of BIM uses and BIM objectives using the document entitled: "BIM Objectives Definition" **[Annex B]**
- The document "The uses of BIM" can be used to define the BIM uses and objectives (Kreider, Ralph G., and John I. Messner, 2013).

DESIGN PHASE

The sooner all the design teams (Architects, Engineering offices, Facility Manager) are completed, the better and the easier the key decisions concerning interoperability and collaboration will be taken.

A. Each design stakeholder appoints a person in charge of the BIM model called BIM discipline manager. If a stakeholder takes in charge the BIM model of another party, it is stated in his contract.

- The BIM discipline manager is known and a contact list is developed. Their main contact is the BIM process manager, who is in charge of defining the collaboration rules and ensuring that they are followed.
- A BIM coordination sheet has to be developed.

B. Based on the BIM objectives, the BIM requirements are determined by the BIM process manager and the BIM discipline managers. **Modelling requirements and content must be presented in all design contracts in a binding and consistent manner.**

- Define the exchange file formats and methods. The file format can differ according to the stakeholders involved in the exchange and their software products.
- Define the level of development expected at each important stage **[Key Exchange]**
- Plan the exchanges, define deadlines and moments when the models are frozen (legal aspects, clash detections, collaboration meetings)
- Define the structure, the naming conventions and the organisation of components/documents (language, classification system, organisation of tables). The codification has to be taken into account as early as possible into the process in order to enhance efficiency of the exchange process.

C. The coordinate system and grid lines used by all stakeholders are exactly the same. The design stakeholders determine together a common origin XYZ. In order to avoid human errors (negative coordinates), the modelling area is defined within the XY positive area and the elevation Z is documented. **No change without sufficient reason. All changes must be agreed by all parties (including the BIM process manager).**

- The base location of the project is documented using at least two known points. XYZ of each point are presented in source and target system.
- The BIM process manager has to verify if the location of the model is coordinated between the stakeholders.

D. As soon as a new stakeholder joins the project, a contract concerning the BIM needs and duties is signed. This stakeholder has to:

- Understand the defined aims of the BIM
- Receive a list of the software products used
- Receive the contact list
- Be informed about the exchange process
- Define with the BIM process manager the best file format, handing procedure and timing.

Task of the BIM process manager

- Create a BIM contact list using the document entitled "*Project BIM Contact List*" **[Annex C]**
- Create a BIM coordination list using the document entitled "BIM Coordination Information Data sheet" **[Annex D]**
- Define with the BIM discipline managers the requirements:
  - *Generic Exchange [X.X] Model Use Requirements* **[Annex E]** *for the exchanges of the design phase*
  - *Generic Exchange [Design/Construction] Level Of Development Requirements* **[Annex F]** *part design*
  - *Naming Conventions* **[Annex G]**
- The website "project task" developed by the ORI (http://app.projecttasks.be/Home) can help to define the imperative exchanges in relation to the tasks that have to be fulfilled.
- Define the origin of the models and check its implementation (model exchange)

CONCEPTUAL PHASE

1. EXCHANGE D1.1

Table 2: Requirements for exchange D1.1

Authoring Party	Architect
Receiver:	Engineering Offices
Expected Content:	¤ Preliminary study ¤ Design principle: modulation ¤ Geometric model

2. EXCHANGE D1.2I

Table 3: Requirements for exchange D1.2i

Authoring Party	Engineering Offices / Consultants
Receiver:	Architect
Expected Content:	¤ Preliminary study (by field) ¤ Design principle (by field – structure, energy,…) ¤ Geometric model (by field) based on architectural model ¤ Notes/Comment about architectural model ¤ Clash detection with architectural model ¤ Report clash detection

3. EXCHANGE D1.3

Table 4: Requirements for exchange D1.3

Authoring Party	Architect
Receiver:	Facility Manager
Expected Content:	¤ Preliminary study ¤ Indicative list of preliminary material choices ¤ List of key design principles and choices ¤ Simple geometric model

4. EXCHANGE D1.4

Table 5: Requirements for exchange D1.4

Authoring Party	Facility Manager
Receiver:	Architect
Expected Content:	¤ Analysis of the preliminary design from an FM perspective ¤ List of suggested changes that can/should be made in the design in order to avoid major flaws or errors in the building operation stage

5. EXCHANGE D2.0 (PLANNING PERMIT)

Table 6: Requirements for exchange D2.0 (Planning Permit)

Authoring Party	Architect (+Engineering Offices)
Receiver:	Administration
Expected Content:	¤ Descriptive notes (materials and construction principles) ¤ Table of operating and gross space area ¤ Official documents needed by the administration based on models and documents

PREPARATION PHASE

6. EXCHANGE D2.1

Table 7: Requirements for exchange D2.1

Authoring Party	Architect
Receiver:	Engineering Offices
Expected Content:	¤ At least previous content [exchange 1.1] + [exchange D1.2i] + Update ¤ At least copy of documents [exchange 2.0] (Planning Permit) ¤ Reports/comments from the administration ¤ General plans/ model ¤ Detailed design/ model

7. EXCHANGE D2.2I

Table 8: Requirements for exchange D2.2i

Authoring Party	Engineering Offices / Consultants
Receiver:	Architect
Expected Content:	¤ At least previous content exchange [D1.2i] + Update ¤ General plans/ model (by field) ¤ Detailed design/ model (by field) ¤ Pre-coordinated model (clash detection, reports, solutions)

8. EXCHANGE D3.0

The distinction between D3.0a and b is used to allow a more specific definition of the documents used for the Tender and documents and are provided to the third party control office in order to receive their advices.

Table 9: Requirements for exchange D3.0b

Authoring Party	Architect
Receiver:	Third party control office
Expected Content:	¤ Frozen version of the model

TENDER PHASE

A. The tender document contains, in addition to the information contained in classical documents, at least:

- A coordinated design model (Architects + Engineering offices) without any relevant clashes.
- The individual model from each disciplines and their M.IDS.
- The modelling of elements corresponds to the real construction elements (geometry, properties). If it is not the case, it is stated in the M.IDS and in the contractual document.
- A document stating the software used by the designer teams.
- A document stating the BIM requirements and the BIM task of the contractor.
- A contact list with information about the BIM process manager and the BIM discipline manager.

In building projects, the Bill Of Quantities (BOQ) is usually produced by the architect and checked by the contractor before submitting his offer.

During the different meetings of the BIM workgroup the idea of using the Architectural Model to determine the quantities needed to construct the building rose. Therefore, the contractors could provide the best price for a given quantity of materials instead of recalculating everything and provide a price for another quantity of elements.

If the contract is stated according to the quantities in the model, the price is also given in accordance to those quantities. However, since the model provides the quantities without taking into account the different measurement specifications, the contractor has to take them into account into its bid. Indeed, the BIM quantities are not strictly equal to the current invoiced quantities. Therefore, the gross quantities delivered by the model should be used as the new invoiced quantities.

It is possible that not all items are integrated in the BIM-model, requiring a separate BOQ.

e.g.: For clients, the quantity surveys are easier

B. A digital copy of all the documents is saved and signed by the different stakeholders, either physically or digitally (e.g.: online service with a digital signature, signature on a disc containing a copy of the digital documents).

C. A report containing the list of documents exchanged is signed by the different parties.

Task of the BIM process manager

- Ensure that the tender documents contain information about BIM uses, software and processes.
- Update the BIM contact list using the document entitled "Project BIM Contact List" **[Annex C]**
- Update a BIM coordination list using the document entitled "BIM Coordination Information Data sheet" **[Annex D]**
- Determine with the BIM discipline managers if the contractor takes the ownership of the architectural/coordinated model (or the Architect continues to ensure his coordinating task)
- Define with the BIM discipline managers the requirements:
  - Generic Exchange [X.X] Model Use Requirements **[Annex E]** for exchanges of the construction phase
  - Generic Exchange [Design/Construction] Level Of Development Requirements **[Annex F]** part construction
  - Naming Conventions **[Annex G]**

1. EXCHANGE B0A

Table 10: Requirements for exchange B0a

Authoring Party	Architect
Receiver:	Contractors
Expected Content:	¤ Descriptive notes (materials and construction principles) ¤ Table of operating and gross space area (update) ¤ Cost estimations (update) ¤ Details ¤ Paying-in Slips ¤ Pre-coordinated BIM model (clash detection, reports and solutions) ¤ BIM models (by fields) ¤ Model with quantities ¤ Frozen version of the model

BUILDING PHASE

A. As soon as a new stakeholder (contractor, sub-contractor) joins the project, a contract concerning the BIM needs and duties is signed. The stakeholder has to:

- Understand the defined aims of the BIM
- Receive a list of the software products used
- Receive the contact list
- Be informed about the exchange process
- Define with the BIM process manager the best file format, handing procedure and deadlines.

1. EXCHANGE B0B

Table 11: Requirements for exchange B0b

Authoring Party	Owner; Architect
Receiver:	Architect
Expected Content:	¤ At least previous content exchange [B0a] + Update (Architect) ¤ Contractual documents ¤ Coordinated model (clash detections, reports and solutions) ¤ Updated BIM uses and requirements (All stakeholders) ¤ Updated contact list (All stakeholders) ¤ New information concerning the exchange process (All stakeholders)

2. EXCHANGE B1.0

Table 12: Requirements for exchange B1.0

Authoring Party	Contractor
Receiver:	Architect
Expected Content:	¤ Relevant part of BIM construction model ¤ Reports/comments from the contractors

3. EXCHANGE B1.1

Table 13: Requirements for exchange B1.1

Authoring Party	Architect
Receiver:	Engineering Offices / Consultants
Expected Content:	¤ At least previous content [exchange 2.1] +[exchange 2.2i] + Update ¤ Reports/comments from the contractors ¤ Relevant part detailed design/ model

4. EXCHANGE B1.2i

Table 14: Requirements for exchange B1.2i

Authoring Party	Engineering Offices / Consultants
Receiver:	Architect
Expected Content:	¤ Reports/comments on modifications ¤ Relevant part of technical design/ model

5. EXCHANGE B1.3

Table 15: Requirements for exchange B1.3

Authoring Party	Architect
Receiver:	Facility Manager
Expected Content:	¤ Overview of how previous exchange [exchange B1.3] +[exchange 1.4] has been handled + Update ¤ Detailed design/ Model

6. EXCHANGE B1.4

Table 16: Requirements for exchange B1.4

Authoring Party	Facility Manager
Receiver:	Architect
Expected Content:	¤ Analysis of the detailed design from an FM perspective ¤ List of suggested changes that can/should be made in the design in order to avoid major flaws or errors during the building operation stage ¤ Operational cost analysis over the next 10 to 20 years (depending on project type)

7. EXCHANGE B2.0i

Table 17: Requirements for exchange B2.0i

Authoring Party	Architect, Engineering Offices
Receiver:	Contractors; Third Party Control Office
Expected Content:	¤ Economic analysis ¤ Execution plans from model ¤ Detailed plans from model ¤ Amending plans from model ¤ Coordinated model (Clash detection, reports and solutions)

8. EXCHANGE B3.0i

Table 18: Requirements for exchange B3.0i

Authoring Party	Contractors
Receiver:	Architects; Engineering Offices; Third Party Control Office; Project Manager
Expected Content:	¤ As-constructed documents/ model ¤ Monitoring field progress

9. EXCHANGE AS.B

Table 19: Requirements for exchange As.B

Authoring Party	Contractors, Architect
Receiver:	Owner (other stakeholders provisional acceptance); Third Party Control Office
Expected Content:	¤ As-built model (with As-built M.IDS) ¤ As-built details

MAINTENANCE PHASE

Ideally, the preliminary design model as well as the execution plans have passed via the Facility Manager during the overall BIM process (see exchanges D1.3, D1.4, B1.3 and B1.4 in the BIM process diagram). These exchanges allow the Facility Manager and the architect to collaboratively improve the building design, so that unexpected high operational costs can be avoided from the very start of the architectural design and construction project. These exchanges (D1.3, D1.4, B1.3 and B1.4) are one-directional exchanges: the architect supplies the Facility Manager with the most recent design status and principles at that stage, and the Facility Manager mainly returns a list of change recommendations. These change recommendations are to be produced relying on experiences, knowledge and rules of thumb regularly available in an FM context.

At the end of the construction (Build) process, the information about the building is handed over by the owner to the Facility Manager (exchange M.0). This includes first and foremost an as-built model, supplied in the native format originally used (result of exchange AS.B). This as-built model needs to contain the information that is useful for the operational phase, at the highest Level of Development possible, namely LOD500: basic geometry, material data, equipment and installation data, (infra) structural data. In addition, a human-readable file is delivered (CSV, IFC, XML) that contains as much as possible of the BIM data. Ideally, this data file can be imported automatically into existing Facility Management Information Systems (FMIS). This second process is similar to the COBie procedure used in the US.

1. EXCHANGE M.0

Table 20: Requirements for exchange M.0

Authoring Party	Owner
Receiver:	Facility Manager
Expected Content:	¤ As-built model (native BIM model) ¤ Human-readable transcript file (CSV, IFC, XML) containing as much as possible information from the BIM model ¤ As-built document folder ¤ Copies of the exchange documents built up over the entire design – tender – build process

BIM GLOSSARY

As-built is defined as the record of drawings and documentation defining deviations to the designed information occurring during construction at the end of the project (as defined by PAS 1192-2:2013)

As-constructed defines the defect and deviation to the designed model occurring during construction. The "as constructed" model and its appended documentation are continually updated through re-measurement as construction progresses. This allows for deviation to be reviewed with respect to the following packages and making knowledgeable assessment of impact and resolution (as defined by PAS 1192-2:2013)

Author is the originator of model files, drawings or documents (as defined by PAS 1192-2:2013)

Building Information Model is a digital representation of the physical and functional characteristics of the project (as defined by AIA Document E202 - 2008 - 1.2.1)

Building Information Modelling is a process in which different actors work together, efficiently exchange information (data and geometry) and collaborate to provide a more efficient construction process (e.g. less errors, faster construction. Its use could result in efficient buildings that produce less waste and are cheaper but also easier to operate.

BIM Discipline Manager(s) is one or more individuals responsible for the BIM's Information Management program for one discipline.

BIM Process Manager is the person appointed, initially by the Owner, to perform the Information Management Role.

Industry Foundation Classes (IFC) is a neutral and open specification, object-based file format with a data model developed by building SMART to facilitate interoperability in the architecture, engineering and construction (AEC) industry (as defined by BS 7000-4:2013).

Level of Development (LOD) describes the level of completeness to which a Model Element is developed (as defined by AIA Document E202 - 2008 - 1.2.2)

Model is a three-dimensional representation in electronic format of building elements representing solid objects with true-to-scale spatial relationships and dimensions. A model may include additional information or data (as defined by Consensus DOCS 301 BIM Addendum, US)

Specification is identification of the requirements on objects including the subsequent selection of products during installation and replacement (as defined by BS 8541-4:2012)

BIM ACRONYMS

BIM = Building Information Modelling / Model /Management

Document.IDS or D.IDS = Document Identification and Information Data sheets

eXchange.IDS or X.IDS = Exchange Identification and Information Data sheets

LOD = Level Of Development

Model.IDS or M.IDS = Model Identification and Information Data sheets

BIBLIOGRAPHY

« AEC (UK) BIM Protocol - BIM Execution Plan - Implementing UK BIM Standards for the Architectural, Engineering and Construction Industry ». AEC UK, September 2012.
https://aecuk.files.wordpress.com/2012/09/aecukbimprotocol-bimexecutionplan-v2-0.pdf.

« AEC (UK) BIM Protocol - Implementing UK BIM Standards for the Architectural, Engineering and Construction Industry ». AEC UK, September 2002. https://aecuk.files.wordpress.com/2012/09/aecukbimprotocol-v2-0.pdf.

BIMForum, ed. 2013. *Level Of Development Specification - For Building Information Models.*

BIMForum, ed. 2014. *Level Of Development Specification - For Building Information Models.*

Boton, Conrad, and Sylvain Kubicki. « Maturité des pratiques BIM: Dimensions de modélisation, pratiques collaboratives et technologies ». In SCAN'14, *6ème Séminaire de Conception Architecturale Numérique*, 45 56, 2014.
https://hal.archives-ouvertes.fr/hal-01025675/.

Celnik, Olivier, Éric Lebègue, and Guersendre Nagy. *BIM et maquette numérique pour l'architecture, le bâtiment et la construction*. Paris; Marne-la-Vallée: Eyrolles ; Centre Scientifque et Technique du Bâtiment, 2014.

D. Van Rillaer, J. Burger, R. Ploegmakers, and V. Mitossi. Rgd *BIM Standard.* Version 1.0.1. The Nederlands: Rijksgebouwendienst, 2012.

De Riet, Martijn. « Who Owns the BIM? | AUGI ». *Autodesk User Group International*, January 23, 2013.
http://www.augi.com/library/who-owns-the-bim.

Deutsch, Randy. *BIM and integrated design: strategies for architectural practice.* 1st ed. Hoboken, N.J: Wiley, 2011.

Eastman, Charles M., ed. *BIM handbook: a guide to building information modeling for owners, managers, designers, engineers and contractors*. 2nd ed. Hoboken, NJ: Wiley, 2011.

Hamil, Stephen. « Building Information Modelling and Interoperability ». *Think BIM*, March 28, 2012.
http://ckegroup.org/thinkbimblog/building-information-modelling-and-interoperability/.

Henttinen, Tomi. *Common BIM Requirements Series 1 - General Part.* Vol. 1. 13 vols. Finland: BuildingSMART Finland, 2012.

Henttinen, Tomi. *Common BIM Requirements Series 3 - Architectural Design.* Vol. 3. 13 vols. Finland: BuildingSMART Finland, 2012.

Henttinen, Tomi. *Common BIM Requirements Series 8 - Use of Models for Visualisation.* Vol. 8. 13 vols. Finland: BuildingSMART Finland, 2012.

Järvinen, Tero, and Tuomas Laine. *Common BIM Requirements Series 9 - Use of Models in MEP Analyses.* Vol. 9. 13 vols. Finland: BuildingSMART Finland, 2012.

Järvinen, Tero, Tuomas Laine, Kari Kaleva, and Kimmo Heljomaa. *Common BIM Requirements Series 4 - MEP Design.* Vol. 4. 13 vols. Finland: BuildingSMART Finland, 2012.

Karjula, Jaakko, and Elina Mäkelä. *Common BIM Requirements Series 11 - Management of a BIM Project.* Vol. 11. 13 vols. Finland: BuildingSMART Finland, 2012.

BIBLIOGRAPHY

Karppinen, Annikki, Ari Törrönen, Maria Lennox, Marjo Peltomäki, Mikko Lehto, Jyrki Maalahti, Suvi Sillfors-Utriainen, Markku Kiviniemi, and Kristiina Sulankivi. *Common BIM Requirements Series 13 - Use of Models in Construction*. Vol. 13. 13 vols. Finland: BuildingSMART Finland, 2012.

Kreider, Ralph G., and Messner, John I. (2013). "*The Uses of BIM: Classifying and Selecting BIM Uses*". Version 0.9, September, The Pennsylvania State University, University Park, PA, USA. http://bim.psu.edu.

McPhee, Antony. "*BIM for Owners: The BIM Project Brief*." Practical BIM - Practical Tips on Making BIM Work, November 8, 2012. http://practicalbim.blogspot.fr/2012/11/bim-for-owners-bim-project-brief.html.

McPhee, Antony. "*Collaboration or Coercion: The Design Collaboration Plan*." Practical BIM, November 23, 2012. http://practicalbim.blogspot.com.au/2012/11/collaboration-or-coercion-design.html.

McPhee, Antony. "*Single Project BIM Execution Plan: A Good Idea?,*" November 2, 2012. http://practicalbim.blogspot.com.au/2012/11/single-project-bim-execution-plan-good.html.

McPhee, Antony. "*Standards - Why Don't We Use Them?*" Practical BIM - Practical Tips on Making BIM Work, June 10, 2013. http://practicalbim.blogspot.fr/2013/06/standards-why-dont-we-use-them.html.

McPhee, Antony. "*Utilising Your Office BIM Manual: Participants BIM Plans*." Practical BIM - Practical Tips on Making BIM Work, November 16, 2012. http://practicalbim.blogspot.com.au/2012/11/utilising-your-office-bim-manual.html.

McPhee, Antony. "*Where's the Contractor? BIM Execution Plan for Contractors.*" Practical BIM - Practical Tips on Making BIM Work, November 30, 2012. http://practicalbim.blogspot.com.au/2012/11/wheres-contractor-bim-execution-plan.html.

Middlebrooks, Robert E., and Lorisa L. Behrens. « *A New Collaborative Workflow: Building Information Modeling* ». Heating/Piping/Air Conditioning Engineering : HPAC 81, no 11 (2009): 12,14 15.

Moreau, Simon. 2012. "*Level Of Development.*" BIM 42. November 21. http://bim42.com/2012/11/level-of-development/.

Oakley, Josh. "*Getting a BIM Rap: Why BIM Implementations Fail, and What You Can Do About It.*" AECbytes - Analysis, Research, and Reviews of AEC Technology, April 30, 2012. http://www.aecbytes.com/viewpoint/2012/issue_65.html.

Rajala, Marko. *Common BIM Requirements Series 2 - Modeling of the Starting Situation*. Vol. 2. 13 vols. Finland: BuildingSMART Finland, 2012.

Renou, Jonathan. "IDPD (Integrated Project Developpment Protocol) - Plan de Déploiement Du BIM Au Niveau D'un Projet." HexaBIM.com, March 20, 2015. http://www.hexabim.com/fr/13-exemple-de-plan-d-execution-du-bim/file.

Smith, Brendan. "Protocols What You Need to Know before You Start v1," March 17, 2012. http://thebimmanager.blogspot.com.es/2012/03/protocols-what-you-need-to-know-before.html.

Smith, Brendan. « Protocols what you need to know before you start v1 », 17 mars 2012. http://thebimmanager.blogspot.com.es/2012/03/protocols-what-you-need-to-know-before.html.

Svetel, Igor, Marko Jaric, and Nikola Budimir. « BIM: Promises and Reality ». *Spatium*, no 32 (2014): 34 38. doi:10.2298/SPAT1432034S.

Tauriainen, Matti. *Common BIM Requirements Series 7 - Quantity Take-Off*. Vol. 7. 13 vols. Finland: BuildingSMART Finland, 2012.

BIM PROTOCOL ANNEXES:

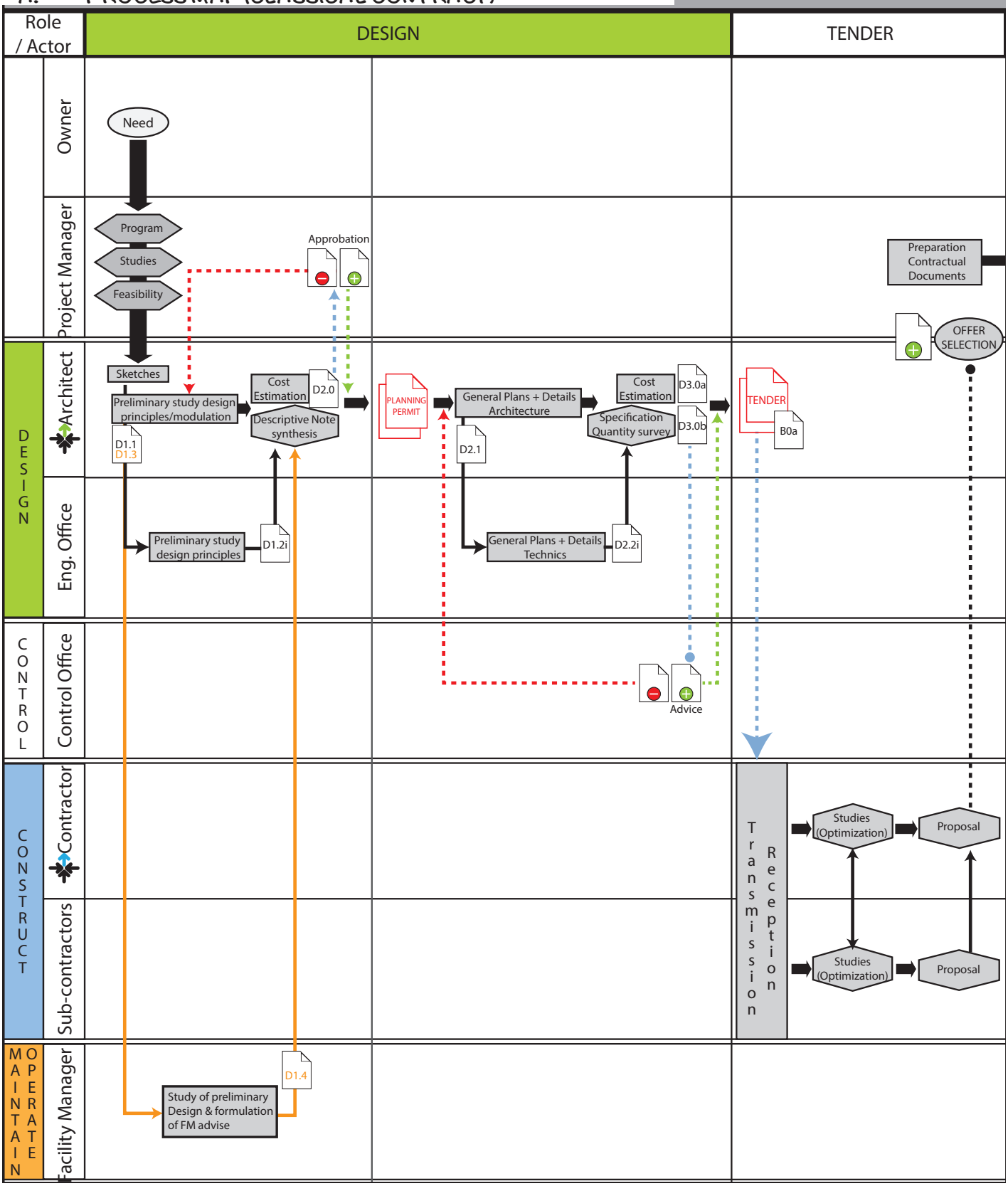
The documents presented in the annexes could be used as templates in order to create a project-specific BIM protocol. Those generic documents can be updated to the project specificities. However, they contain the generic and common information that should be defined and agreed during the design/construction process.

ANNEXES LIST:

A - Process Map (Classical Contract)
B - BIM Objectives Definition
C - Project BIM Contact List
D - BIM Coordination Information Data sheet
E - Generic Exchange [X.X] Model Use Requirements
F - Generic Exchange [Design/Construction] Level Of Development Requirements
G - Naming Conventions
H - Model Identification and Information Data sheets – Model.IDS/M.IDS
I - Exchange Identification and Information Data sheets – eXchange.IDS / X.IDS

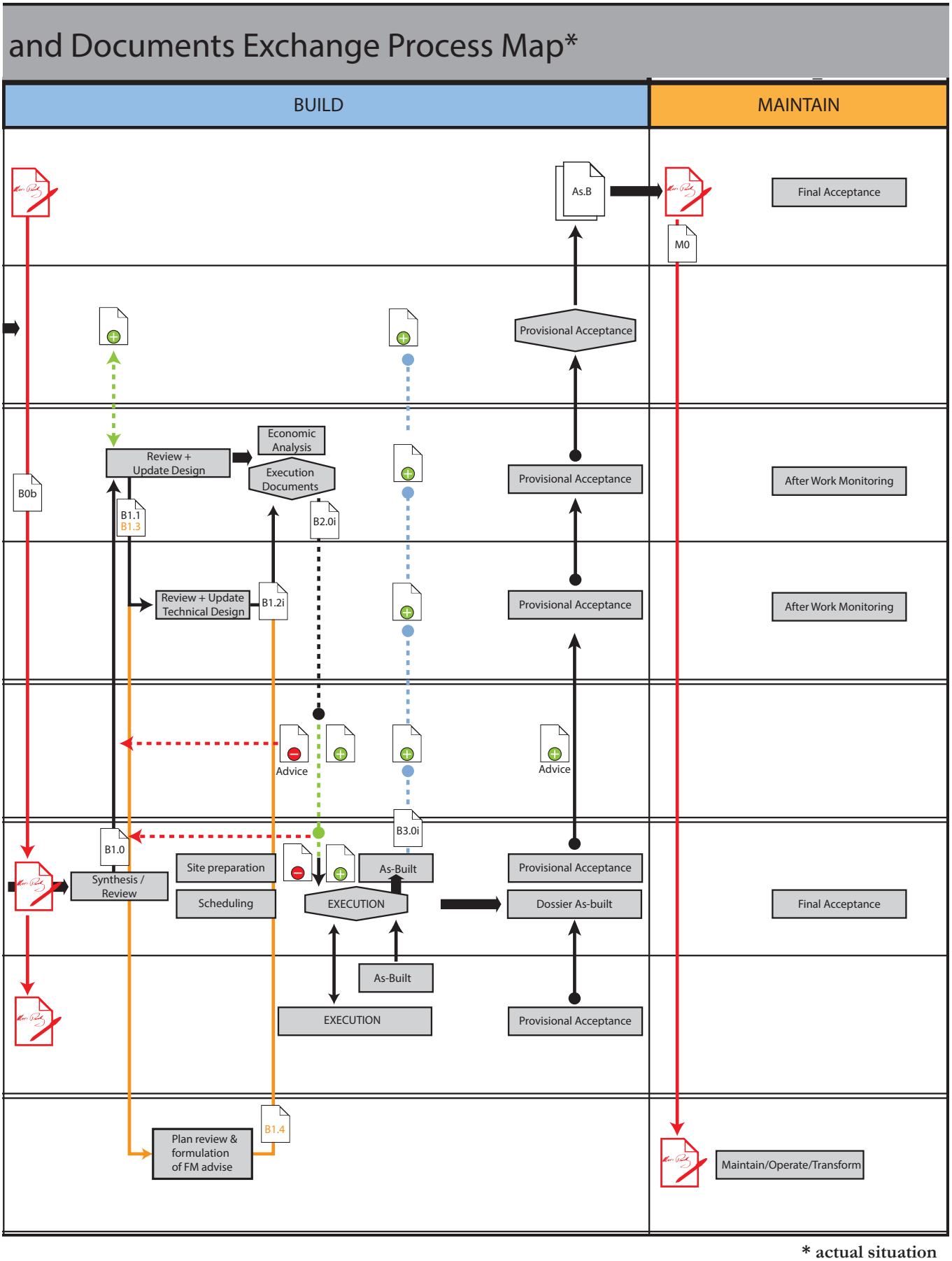
A. BIM Collaboration

A. PROCESS MAP (CLASSICAL CONTRACT)



LEGEND

Leadership · Coordinate · Execute · Documents · Agree · Disagree · Accepted · Mandatory


and Documents Exchange Process Map*
BUILD
MAINTAIN
As.B
Final Acceptance
M0
Provisional Acceptance
Economic Analysis
Review + Update Design
Execution Documents
B0b
B1.1
B1.3
B2.0i
Provisional Acceptance
After Work Monitoring
Review + Update Technical Design
B1.2i
Provisional Acceptance
After Work Monitoring
Advice
Advice
B3.0i
B1.0
Site preparation
As-Built
Provisional Acceptance
Synthesis / Review
Scheduling
EXECUTION
Dossier As-built
Final Acceptance
As-Built
EXECUTION
Provisional Acceptance
B1.4
Plan review & formulation of FM advise
Maintain/Operate/Transform
* actual situation
Facility Management
Flow
Contract

B. BIM OBJECTIVES DEFINITION

BIM Objectives			
Objectives	**Method (How)?**	**Exchange or Phase**	**Achieved by**

C. PROJECT BIM CONTACT LIST

Contact List				
BIM process manager				
Name	**Email**	**Phone**	**Additional Comment**	
NAME Surname	*email@email.com*			
BIM Discipline Managers				
Party	**Name**	**Email**	**Phone**	**Additional Comment**
Architect	*Name Surname*			
Engineering Office 1	*Name Surname*			
Engineering Office 2	*Name Surname*			
Facility Manager	*Name Surname*			

D. BIM COORDINATION INFORMATION DATA SHEET

BIM Coordination Information Data sheet[3]				
Party	**Software Component**	**Model**	**Software System**	**Version**
	Model Authoring	Architectural		
	Model Authoring	Structural		
	Model Authoring	MEP		
	Model Authoring	Coordination		
	Model Authoring	Construction		
	Model Authoring	As-built		
	Model Authoring	*Other*		
	Model Integration			
	Model Mediation			
	Model Visualisation			
	Model Sequencing			
	Model Quantity			
	Communication and Collaborative messages			
	Document Management			
	Design Management			
	Tender Management			
	Construction Management			
	Cost Management			
	Operation/Installation Management	As-built		
	Quality Control			
	New item	New item		

[3] Based on IPDP (Integrated Project Delivery Protocol) (Renou, 2015)

E. GENERIC EXCHANGE [X.X] MODEL USE REQUIREMENTS

Exchange [X.X]: Model Use Requirements:			
Authoring Party	*Stakeholder A ; Stakeholder A BIM discipline Manager*		
Receiver:	*Stakeholder B ; Stakeholder B BIM discipline Manager*		
Deadline	*Dd/mm/yyyy or x days after exchange [x.x]*		
Handling procedure:	¤ Email Name: ……..	✖ Collaboration platform Name: *platform.com*	✖ Other: *Notification email to contact@email.com*
Use of BIM[4]	¤ Generate Quantities ¤ Validate/Control Quantities ¤ Fabrication support ¤ Prescribe systems (HVAC, MEP) ¤ *New items*		
Expected Content:	*Depends on the phase. Propositions by phases are made within the BIM handbook.* ¤ Descriptive notes (materials and construction principles) ¤ Table of operating and gross space area ¤ Cost estimations ¤ Pre-coordinated BIM Model ¤ BIM models (by fields) ¤ Details ¤ Slips ¤ Quantities ¤ Clash detection, reports and solutions ¤ ……		
File format:	***Model:*** *Native format version 2015* ***Calculation sheets:*** ***Reports:*** ***Plans/Details*** ***Add new items***		
Additional Task	¤ Organize a coordination meeting (clash detections, new decisions)		

[4] The document "The uses of BIM" can be used to define the BIM uses and objectives (Kreider & Messsner, 2013)

F. GENERIC EXCHANGE [DESIGN/CONSTRUCTION] LEVEL OF DEVELOPMENT REQUIREMENTS

This document allows to clearly define the requirements concerning the level of development for:
- Each element/category
- At each exchange of the Design/Construction phase

Exchange [Design]: Level of Development Requirements:										
Category[5]	**Subcategory**	**Exchange**								**Additional Comments**
		D1.0	**D1.1i**	**D2.0**	**D2.1**	**D2.2i**	**D3.0**	**B0.a**	**B0.b**	
Space	*Room*	*100*			*200*			*350*		*Rooms smaller than 1m² are not modelled* *Rooms bigger than 40 m² are sub-divided*
Structure	*Wall*									*Distinction between bearing and non-bearing walls should be made.*

Exchange [Construction]: Level of Development Requirements:										
Category	**Subcategory**	**Exchange**								**Additional Comments**
		B0	**B1.0**	**B1.1**	**B1.2i**	**B2.0l**	**B3.0i**	**As.B**	**M.0**	
Space	*Room*	*350*						*500*		*Rooms smaller than 1m² are not modelled* *Room bigger than 40 m² are sub-divided*
Structure	*Wall*									*Distinction between bearing and non-bearing walls should be made..*

[5] The category and the subcategory depends on the classification system chosen. The correct numbering has also to be stated in the category.

G. NAMING CONVENTIONS

File naming convention:	
File Type	**Naming Convention** *(explicit naming or reference to standard)*

Elements/Objects naming convention:	
File Type	**Naming Convention** *(explicit naming or reference to standard)*

H. MODEL IDENTIFICATION AND INFORMATION DATA SHEETS – MODEL.IDS/M.IDS

The "M.IDS" is a document that defines and completes a specific BIM (model). Each model has its own M.IDS that identifies the model and documents its content. A model without M.IDS is useless because one does not have any information about its content and limitations.

Model Identification	
Model.IDS #	
Date:	
Version:	
Author:	
Model Owner:	

Project Information	
Project Name	
Owner	
Project Number	
Address/Location	

Version description

File Name	Model Type	Author	Version	File Format	Date of creation	Date of last update
Filename	architectural	author	Version 1	.format	Dd/mm/yyyy	Dd/mm/yyyy
Filename2	architectural	author	Version 2	.format	Dd/mm/yyyy	Dd/mm/yyyy

Coordiantion Status (with other models)

File Name	Model Type	Author	Version	File Format	Date of creation	Date of last update
Otherfile	MEP	Engineering 1	Version 2	.formatmep	Dd/mm/yyyy	Dd/mm/yyyy
Otherfile2	structure	Engineering 2	Version 3.1	.formatstruct	Dd/mm/yyyy	Dd/mm/yyyy

Content Description	
Present in the model	**Not Present in the model**

LOD Description			
Category[6]	**Subcategory**	**LOD**	**Additional Comments**
Space	Room		Rooms smaller than 1m² are not modelled Rooms bigger than 40 m² are subdivided
Structure	Wall		Distinction between bearing and non-bearing walls should be made.

Comments / Remarks *(specific modelling method, exception to requirements)*
Curved roof [identification_number] are not modelled with standard tool

Model Modification List *(each modification has to be listed)*			
Type of modification	**Date**	**Author**	**Version**
Creation of building enveloppe	Dd/mm/yyyy	Author a	Version 1
Add thickness to walls	Dd/mm/yyyy		Version 1
Add elements #xxxx and #yyyyy	Dd/mm/yyyy		Version 1
New building configuration Dd/mm/yyyy	Dd/mm/yyyy		Version 2

[6] The category and the subcategory depends on the classification system chosen. The correct numbering has also to be stated in the category.

I. EXCHANGE IDENTIFICATION AND INFORMATION DATA SHEETS – EXCHANGE.IDS / X.IDS

The "X.IDS" is a document that describes a specific exchange. Each bundle of documents/models that is exchanged has its own X.IDS that documents its content. The X.IDS identifies the exchange itself but also documents a list of the documents exchanged. Furthermore, the X.IDS also allows the receiver to assess/check if the received documents respect the specifications.

Exchange Identification	
eXchange.IDS #	
Date:	
Version:	

Project Information	
Project Name	
Owner	
Project Number:	
Address/Location	

Document List					
Name	**Version**	**Field**	**File Format**	**Author**	**Comments/Limitations related to the content**
Filename	Version 1	Architecture	.format	author	Layers of walls are not present
Filename2	Version 2	Engineering	.format	author	Fire requirements documented

BIM model checklist[7]						
# M.IDS		**Date M.IDS**			**# Version M.IDS**	
Checklist[8]		**[V]**	**[X]**	**[?]**	**Comments**	
Respect BIM specifications						
Models are in the defined file format						
Agreed classification system is used						
Model has floors						
Add new items						

[7] *The Based on Cobim series 3 (Henttinen, 2012)*

BIM model checking					
Checklist[8]	**[V]**	**[X]**	**[?]**	**Comments**	
Models have been checked manually					
Models' checking software had been used					
Add new items					

[8] *This checklist has to be determined by the BIM process manager with the support of the BIM discipline managers*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