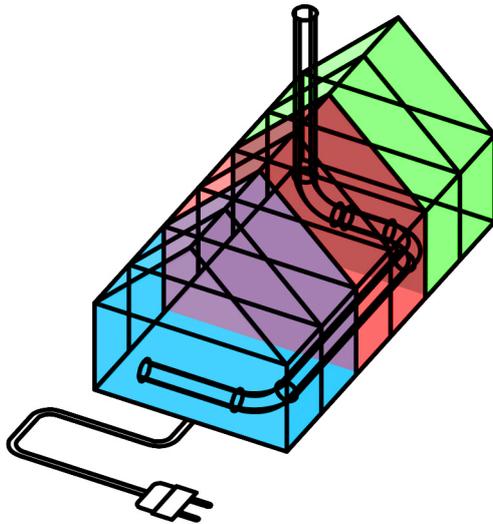


COBIM

Common BIM Requirements
2012

v 1.0



Series 1

General part

Foreword

The publication series “Common BIM Requirements 2012” is the result of a broad-based development project entitled *COBIM*. The need for these requirements arises from the rapidly growing use of building information modeling in the construction industry. During all phases of a construction project, the involved parties have an increasing need to define more precisely what is being modeled and how the modeling is done. “Common BIM Requirements 2012” is based on the previous instructions of the owner organizations and the user experiences derived from them, along with the thorough experience the writers of the instructions possess with model-based operations.

The parties involved in the project are:

Funding providers: Aitta Oy, Larkas & Laine Architects Ltd, buildingSMART Finland, City of Espoo Technical and Environment Services, Future CAD Oy, City of Helsinki Housing Production Office, City of Helsinki Premises Centre, University of Helsinki, Helsingin Yliopistokiinteistöt Oy, HUS Kiinteistöt Oy, HUS Premises Centre, ISS Palvelut Oy, City of Kuopio Premises Centre, Lemminkäinen Talo Oy, Micro Aided Design Ltd. (M.A.D.), NCC companies, Sebicon Oy, Senate Properties, Skanska Oy, SRV Group Plc, Sweco PM Oy, City of Tampere, City of Vantaa Premises Centre, Ministry of the Environment.

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Management: The Building Information Foundation RTS.

The requirements were approved by an executive group consisting of members from the project parties. The executive group acted as committee TK 320 of the Building Information Foundation RTS, and as such, participated actively in developing the content of the requirements and asking for comments from the members of the executive group and from interest groups.

Parties to the © COBIM project.

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1 Main Objectives of Building Information Modeling

Property and construction modeling aims to support a design and construction lifecycle process that is of high quality, efficient, safe and in compliance with sustainable development. Building information models are utilized throughout the building's lifecycle, starting from initial design and continuing even during use and facility management (FM) after the construction project has concluded.

Building information models enable the following, for example:

- Provision of support for investment decisions by comparing the functionality, scope and costs of the solutions.
- Energy, environment and lifecycle analyses for the purpose of comparing solutions, design and objectives of facility management follow-up.
- Design visualization and analysis of construction feasibility.
- Enhancement of quality-assurance and data exchange and making the design process more effective and efficient.
- Utilization of building project data during building operations and facility management activities.

To make modeling successful, project-specific priorities and objectives must be set for models and model utilization. Project-specific requirements should be defined and documented on the basis of the objectives and general requirements set in this publication series.

General objectives of building information modeling include, for example, the following:

- To provide support for the project's decision-making processes.
- To have the parties commit to the project objectives by means of using the building information model.
- To visualize design solutions.
- To assist in design and the coordination of designs
- To increase and secure the quality of the building process and the final product.
- To make the processes during construction more effective.
- To improve safety during construction and throughout the building's lifecycle.
- To support the cost and lifecycle analyses of the project.
- To support the transfer of project data into data management during operation.

“Common BIM Requirements 2012” covers targets for new construction and renovation, as well as the use and facility management of buildings. The minimum requirements for modeling and the information content of models are included in the modeling requirements. The minimum requirements are intended to be observed in all construction projects wherein the use of these requirements is advantageous. Besides the minimum requirements, additional requirements can be presented on a case-specific basis. Modeling requirements and content must be presented in all design contracts in a binding and consistent manner.

The publication series “Common BIM Requirements 2012” consists of the following documents:

1. General BIM Requirements
2. Modeling of the Starting Situation
3. Architectural Design
4. MEP Design
5. Structural Design
6. Quality Assurance
7. Quantity Take-off
8. Use of Models for Visualization
9. Use of Models in MEP Analyses
10. Energy Analysis
11. Management of a BIM Project
12. Use of Models in Facility Management
13. Use of Models in Construction
14. Use of Models in Building Supervision

In addition to the requirements of individual fields, each participant in a building information modeling project must be acquainted at a minimum with the General BIM Requirements (Series 1) and the principles of Quality Assurance (Series 6). The person in charge of the project or the project's data management must have comprehensive command of the principles of building information modeling requirements.

2 Introduction

This document describes the basic requirements and concepts of the use of Building Information Modeling (BIM) in architectural projects. Modeling is part of the design process parallel to other methods such as detail drawings, schedules and building descriptions. These requirements address only those processes associated with the BIM. All other documents must be created and shared according to appropriate instructions. Some instructions, such as CAD Layering, may also be followed in the modeling. However, since the BIM design applications handle the detail levels, projections, documents etc. based on objects, the use of layering may be different than the traditional CAD drafting. The layering guidelines must therefore be adjusted accordingly.

The tender documents should define how the BIM is going to be used in the project, the respective responsibilities of different parties and the verification methods. Additional information can be found in Series 11 Management of a BIM Project. It is recommended that the geometry and information content requirements of the models be clear before the selection of AECs. Otherwise, the technical modeling and data management can compromise in BIM quality and how effectively the model can be used. General requirements for BIMs are represented in Appendix 1. More detailed information can be found in the other series of these requirements.

This document deals with same issues as discipline-specific documents, but on a more general level. Discipline-specific documents have always a higher priority in interpretations.

3 General Technical Requirements for BIM

3.1 Software

In public projects, all software that has a minimum of IFC 2x3 certification may be used for modeling. This requirement can be overridden with project requirements. Designers need to specify all the BIM software and their versions, and what version of IFC they support in the tender documents.

The project participants shall mutually agree on all version or software changes during the project. A testing phase must be carried out before the final decision of adaption to new versions. The use of non-IFC-certified file formats at the official decision points of the project must be accepted by the project management. Simultaneously all mutually agreed data exchange methods and formats may be used in the daily work.

Guideline

In some cases, the Client can specify the software used in the project. For example, construction companies are developing their own BIM processes around specific design software solutions and they may require the use of these design tools. Moreover, the Client may have specific software demands if the project has exceptional modeling requirements or there is for example process development in parallel to the project.

3.2 Release of the BIM

All models are released during the project in the IFC format. In addition, a native file format model may be required simultaneously. Methods of distribution will be agreed upon for each project. At the end of the project all the designs and electronic documents including IFC and native format BIMs will be delivered to the Client as described in the contracts. The Client is entitled to use the models according to the same terms as traditional project documents.

Prior to release of the BIM and sharing it to other disciplines at official release points, all parts and modeling components that are not relevant to the design must be removed from the model. This also includes all referenced models from other disciplines. Each model must contain modeling elements that are created or added only by the releasing discipline.

The Inventory Model makes an exception to this requirement. In renovation projects, the Inventory Model should be used a base model for the Architectural BIM. However, the initial Inventory Model has to be archived separately in order to be used for checking or historical documentation.

Guideline

The IFC files should be compressed (e.g. zipped) when they are shared within the project. This operation can reduce the file size by up to 80%. Even smaller file sizes can be achieved by using

an IFC file optimization program in addition to the file compression utility. This is recommended in especially large projects. Native format model files may be compressed as well, but in most cases the effect is less pronounced.

3.3 Coordinates and Units

It is recommended that the coordination base of the project is determined such that the entire modeling area is on the positive side of the XY-axis and the origin of coordinates is located near the drawing area. The coordinates are typically determined by the architect.

Guideline

It is not recommended to use the municipality or state coordinate system since a base point that is located far away from the modeling area causes problems for most design software.

Negative coordinates are no longer a technical problem. Nevertheless, in order to avoid human errors, it is recommended to avoid them. Negative coordinates in particular, may also cause unnecessary difficulties on the construction site.

Another option to define the XY-origin point is to set it at a certain distance from building gridlines. This option is justified in cases when the building's location may change during the design. Even in this case, it is important to document the position of the origin and the x-axis direction with respect to the map coordinates.

The base location of the project coordinate system is documented by using at least two known points. The X and Y coordinates for each documented point is presented in both source and target systems. Another option is to identify a single-point and the rotation angle. However, it is noted that especially at larger distances the rotation angle will always lead to inaccuracies, which may have an effect in the construction phase.

Guideline

When needed, the transformation from the source to target coordinate system can be made using the Helmert transformation process.

The Z position of the BIM is the same as the actual elevation of building. The unit of measurement used in BIM is millimeters. Rotation angles are always documented with at least two decimal places.

Guideline

Each building on the plot is modeled into same XY coordinate system. Building elevations are determined in absolute elevations in the source coordinate system, but it is possible to agree otherwise if it better serves the project needs. The coordinate system will be agreed upon and documented at the beginning of the project and cannot be modified during the project without a sufficient reason. Any changes must be approved by all parties as well as the project manager.

The site model is created using the same coordinate system as the buildings. The site model includes the site environment, vegetation, traffic areas and site structures. This requirement may, however, differ in projects that involve large-scale infrastructure.

Once the coordination system has been agreed, the Inventory Model(s) and reference material (for example, laser scanning) must be changed into the same coordinate system. It is possible and reasonable to agree that the coordinate system used in the inventory BIM will be used for the design models as well.

After the definition of the coordinate system, it is mandatory to test the compatibility between the disciplines. For this test, one can use a simple doghouse-type model in which all the design disciplines create a couple of buildings or mechanical system parts, so that it can be clearly seen that the models are in same position. In addition, with the current modeling process, it is necessary to ensure that the XY-position and angle of 2D drawings generated from the models match the BIM.

3.4 BIM Accuracy

Before the detailed Building Element BIM phase, the model can be created using nominal dimensions for model components. For example, the doors and windows in the Architectural BIM may be modeled without the necessary installation gaps, which could be added in later phases of the project. Nevertheless, it is essential that the modeling principles used are carried out consistently. In the detailed Building Element BIM all components will be modeled with real dimensions.

All models from Site Models to As-Built Models are made with highest reasonable level of accuracy. For example, in Inventory Models, absolute accuracy (e.g. small slant of walls, inclinations and changes of thickness) might make the models difficult to use, and therefore tolerances that are acceptable for the construction are also allowed in the models.

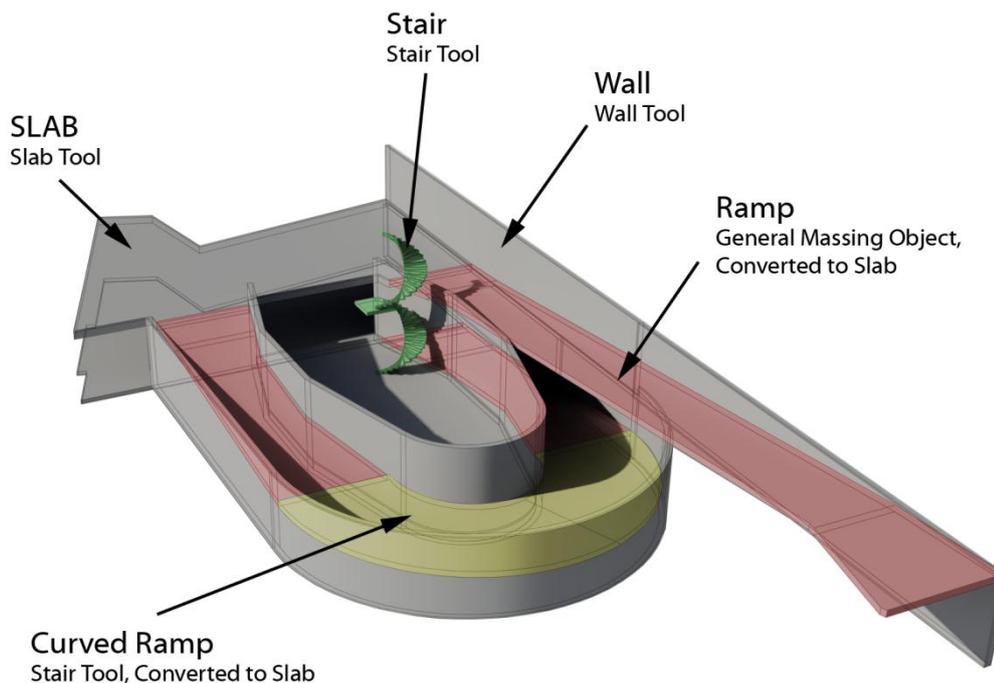
Guideline

The accuracy of the models follows the principle of expediency. In Spatial Models the dimensional accuracy can be the same as in traditional drafting. Since the actual form and size of the building may still be unclear, a 100-200 mm grid may be an appropriate level of accuracy. The selected measurement system must be used consistently. It is also worth noting that the more accurate the original model, the easier it is to continue to work with it throughout the project.

The dimension accuracy of building elements may also be associated with the model's intended use. For example, if the Architectural BIM is used for thermal analyses, the walls must connect to each other at the corners, since even a small gap can significantly interfere with the simulation. Accuracy requirements should be mutually agreed and all disciplines must comply with the agreed practice.

3.5 Modeling Tools

All model elements should be modeled using the intended components and tools, i.e. walls are modeled with wall tools, slabs with slab tool etc. If the specific tool is not available or it is otherwise not suitable, the component will be modeled using a suitable work-around method which is documented in the Models Description Document. More detailed instructions are presented in the Discipline-specific BIM requirements.



An example of a curve shaped ramp that has been modeled by applying the suitable tools of the BIM software. Micromedicum / Senate Properties, Arkkitehtuuritoimisto Heikkinen-Komonen Oy.

3.6 The Buildings, Floor Levels and Divisions

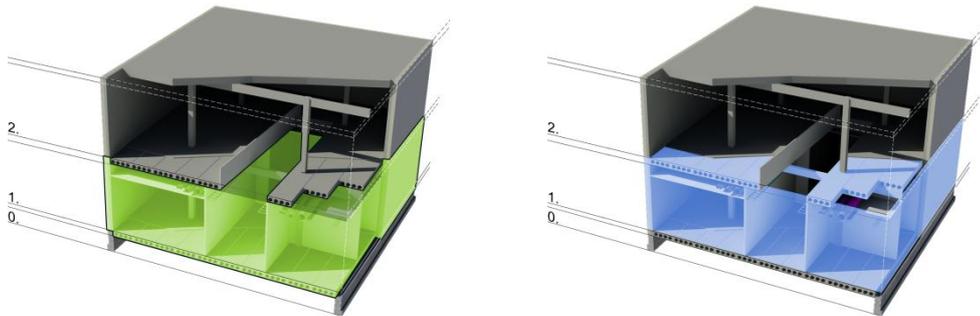
A basic rule is that all disciplines will use a modeling method wherein the model is split by floor level and all model elements belong to correct floor, even though modeling programs could support a different approach. There are many reasons for this: model based analyses are often done by floor, construction sites deal mainly with floors, and facility and property management also use floor divisions. This does not mean that the BIM should be divided into separate models or files by floor,

only the components in the model are split and aligned to appropriate floors. From project to project it is possible to make exceptions to this requirement if needed.

Each separate building will be handed over as an independent model. If necessary, the building can be divided into multiple parts which will be agreed between the project team. Each building is normally handed over as a single model in the IFC and native formats. Building services systems are sometimes delivered as separate models for each floor and system. In very large buildings, architectural or even structural models sometimes have to be divided into separate models by floor.

The concept of a floor is slightly different between the different disciplines. This might be a bit confusing especially between the architectural and structural disciplines, since they deal with same elements. The following guidelines should be followed in modeling:

- In the Structural BIM, each floor contains the horizontal structures above and the vertical structures that support them. The basement floor slab together with the foundations belongs with a separate floor, and the top floor of the model also includes roof structures. The structural BIM contains also those bulky surface structures that are essential for the load-bearing capacity of the structure such as fire insulations.
- In the Architectural BIM, each floor contains the floor slab and its surface structures as well as the suspended ceilings and bulky acoustical structures in the ceilings. The architect does not need to model the foundation, but the base structure should be modeled at least above the ground level. Roof and roof structures are modeled as a separate floor. The roof equipment and accessories are normally not modeled unless otherwise agreed on.



The differences in the modeling of the floor is illustrates by the two images above; Architectural BIM on the left and Structural BIM on the right.

3.7 Naming and Archiving of the BIM

The CAD instructions provided by the Client must be adhered to as applicable when naming the models. All published versions of the BIM are archived in the project as agreed.

3.8 BIM Specification

Each discipline has to maintain a Model Description Document. The document is a description of the contents of the model and it explains the purpose for which the model has been published and what the degree of precision is. The description document contains information about the modeling software used, the different versions created from the original model, and exceptions to these requirements. In addition, all naming conventions used, the maturity of the content and any restrictions on its use are documented in the description.

The description document is published in parallel with the BIM, and it has to be updated whenever any changes that affect the content of the description occur in the model.

Guideline

All changes must be documented in the Model Description Document so that different parties can find them. At official publishing points, the publisher is responsible for the consequences caused by incomplete or incorrect documentation. The responsibilities are recorded in contracts and under general terms and conditions. In the case of Working Models, the use of the description is more explanatory, and therefore the requirements are considerably lower.

The naming of the Model Description must be such that it can be associated to the equivalent BIM.

3.9 Role of the BIM Coordinator

A BIM Coordinator must be appointed to each project. The Coordinator can be either the Head Designer, or someone chosen by the Head Designer or project management. The BIM Coordinator's tasks are overlapping both with the Head Designer and Construction Manager, and in many cases the Coordinator supports both parties in their core activities. Moreover, the Coordinator's tasks are often related to technical issues and therefore require a profound knowledge of BIM software and processes. The Coordinator's role is described further in Series 11, 'Management of a BIM Project.'

The BIM Coordinator takes care of the combination the design models and reports faults to the Head Designer and to rest of the design team. The Head Designer is responsible for the coordination of the design work of different disciplines as described in the official project task lists.

3.10 Publishing of Models

At the official release points of the project, such as building permit application and construction cost estimation, the BIM and the documents that are produced from it are important tools for decision making. In a pure BIM-based design process, the BIM and design cannot be separated and therefore they should be publishable at the same time.

Guideline

Documents should primarily be based on the BIM itself. The model will be published simultaneously with, or before the documents. During the design phase, documents are published much less frequently than BIMs. This allows the active use of BIM in the design development phase instead of as a passive deliverable.

This should be considered in the project schedule. If only the document publication date is scheduled (as in traditional process) there is a risk that model checking and analysis will not have the optimal effect, and many of the benefits of the BIM are wasted.

When releasing a BIM, it is essential that it is conducted in a controlled way and includes the following steps:

- Model will be published for a particular purpose, and the publication is usually triggered by the project planning schedule.
- The decision to release the BIM is followed by the preparation of the model, BIM specification and sometimes also the building specification and other material that is related to the model.
- Before the release of the model, Quality Assurance is carried out as described in Series 6. It is important that the various documents and models are consistent.
- Finally, the release package will be published, for example, by uploading it to the project server. It has to be taken into account that all related analyzes and other material must be able to connect/link later clearly to the package.

The schedule for publications in all stages should be agreed at the beginning of the project and there should be sufficient time and resources reserved for the quality assurance process at each release point.

3.11 Working Models

The official BIM publishing and quality assurance steps take place only during certain stages of the design process.

It is required to share BIM-based information between the project team during the whole design process. Most of the time, this information does not have to go through the extensive quality assurance process previously described, as long as the limitations in the BIM are informed to all parties. Working models are supposed to be a flexible and rapid method to exchange design information and to represent the intended design solutions, space reservations, specific details, etc.

Guideline

Working models may also be sent to other parties when needed, but in well-organized BIM projects, the models are regularly saved into a shared data store instead. The update cycle is determined by the phase and needs of the project, and typically ranges from one to four weeks. These models do not have to be fully audited, and are thus suitable only for limited purposes. The

publisher of a working BIM must make the status of the model clear. The BIM specification document is an essential part of working models. It contains information about the maturity of the model and describes its content and purpose.

3.12 Quality Assurance of BIMs

Each discipline is responsible for the quality assurance of the Working Models and is supervised by the BIM Coordinator. Working models are always more or less unfinished, and so the errors in BIM are acceptable. Nevertheless, each designer has to ensure the technical quality of its own BIMs and ensure that they do not contain any other than the normal errors and incompleteness of that design phase.

In official quality assurance points set by the Client, the BIMs are checked according to the requirements described in Series 6 'Quality Assurance'. The quality requirements in these checkpoints are much higher compared to that of working models, and each discipline is responsible for checking its own BIMs prior to publishing the model. The official quality assurance of the BIMs is carried out by BIM Coordinator or other entity specified by the Client.

4 Generation and Utilization of Models at Different Project Stages

This chapter presents the use of models at different stages of the construction process. The division into stages and different tasks are only presented from the perspective of BIM. The actual requirements for the content of BIMs are described in the requirements for different disciplines (Series 3 to 5).

4.1 Needs and Objectives

During this stage, the needs and objectives of the owner and end users of the property are assessed. On the basis of surveys, alternatives are assessed and decisions concerning the operating model are made in order to attain the objectives of the project - for example new construction or renovation.

The needs and objectives assessment stage does not necessarily involve a geometric model. However, projects should aim towards a Requirement Model in which at least the principal space requirements are recorded in electronic form. This would allow for an automated system for checking the designed areas and possibly also the generation of space objects in the design software. The incorporation of principal space requirements into an electronic design program would also significantly facilitate their management during the design process.

4.1.1 Area and volume, main activities, site requirements

Many of the most important project decisions are done in its early stages. This stage generates the initial data for the design process: the project's budget and schedule objectives as well as overall objective for scope; gross area, volume and the total areas of different activities. The requirements relating to the site, from which the site or the building to be renovated is selected, are also considered at this stage. Since actual designs are often not yet available, the essential data for the decision-making is generated through the spatial and functional requirements. In building information modeling this is known as the Requirement BIM.

4.1.2 Space program, total budget, selected site

On the basis of the needs and objectives assessments, the project requirements are processed into the format required for initiating the design process. The defined space requirements must be recorded in an electronic form as comprehensively as possible so that they can be conveniently maintained and used when the design solution is compared against the requirements.

Guideline

Projects normally involve a number of objectives, the direct linking of which into BIM-based work is currently neither possible nor practical. Budget and schedule objectives, for example, are matters for which the use of separate documents is in most cases the only option. The incorporation of document references into the requirements file or database might facilitate their management. However, only a few suitable tools currently exist to serve this purpose and solutions are in practice tailored to each organization and operator.

Regardless of the documentation method, updating the project requirements to reflect the advancement of objectives and design is an important part of the process. All versions of the requirements that are important for decision-making must be retained so that their revision history can be viewed if required.

4.1.3 Requirement BIM

The minimum requirement for the Requirement BIM is a room program in a table format that can be used for comparing the program and the design solutions. The space program must contain the room-specific areas and special requirements. The room program may be complemented by the user and/or the client requirements. The Requirement BIM should be able to present the requirement to the whole building or its division, such as the total energy consumption, cooling, etc. Both the room program and requirements shall be maintained in electronic form so that they can be compared to the design.

The requirements for individual spaces may also be referenced to spatial group or space type properties.

The room program should contain following requirements:

- The net area requirements for each room and, if necessary, size and shape requirements
- The function and users of the room, the essential connections to other rooms
- The requirements for indoor air conditions, sound insulation, lighting, loads, durability, safety and quality.
- The requirements for HVAC systems, electrical systems, fixtures, fittings, equipment, space-sharing components, the interior surface structures.

It is common for the original requirements to change during the design. The changes need to be recorded so that the project files have all the up to date requirements continuously available . A person appointed by the Client will take of the recording.

Different versions of BIM requirements are archived the similar way as other design documents.

4.1.1 Identification of Spaces

A space (or room) is the basic unit of planning and many building elements are in one way or another linked to the space. The 'Space Id' is the most essential property of the room together with the function. Floor area can be calculated from the geometry and other data can be transferred to a database as long as it is taken care of consistent use of the Space Id. The most important information linked to the space is:

- Space Id: This can also be called as the room number, even if letters and special characters can be used as a part of the number. It is a requirement, that all rooms are identified by a Space Id.
- Space Function: This attribute describes the function of the room, for example according the Talo 2000 nomenclature.
- Name of the Space: A descriptive name for the space.

In addition, the space properties may include:

- Space Type: A reference to a technical template that described, for example, ventilation and electrical outlets per person, square meter or workstation.
- Location of the Space: Room number or similar that represents the location of the room.

Guideline

Consistent and careful use of spatial information is essential in order to gain benefits from BIM-based processes. Spatial data is utilized for a number of purposes such as area-based cost calculations, comparison of the design and the room program, energy analysis, and facility management applications.

These concepts are explained in detail in the Series 3 "Architectural Design."

4.1.2 Laws, Regulations and Instructions

Having the relevant laws, regulations and other instructions provided by authorities available in electronic form and linking them into BIM would substantially benefit the review of the design solutions. This unfortunately is not yet possible in Finland but requires extensive development work in cooperation with different authorities. This area has nevertheless been included in the process charts in view of possible future developments.

Currently, procedures remain the same as those applied in a conventional document-based process.

4.1.3 Tasks for the BIM Coordinator

In the early phases of the project, the BIM coordinator is responsible for specifying the projects BIM objectives and to coordinate availability of initial data for the BIM work. If there is no chosen coordinator, these tasks can also be taken care by the Project Manager or Head Designer:

- Review of the targets for BIM and to ensure that the BIM tasks and processes are taken into account in the schedule. In addition, the special requirements of the project are specified.
- Check that all designers have access to the necessary initial data (for example, possible Inventory BIM).

4.2 Design of Alternatives

At this stage the most suitable basic solution is investigated using rough spatial models for alternative designs. The design models from each discipline should always be available each other, which is ensured by agreeing on a sufficiently frequent uploads to the project server. A suitable schedule at this stage could be, for example, linked to the regular design meetings.



A visualization based on the Architect's BIM for communication purposes between the architect and the client. Alberga Business Park / NCC Property Development Oy, Arkkitehtitoimisto Brunow & Maunula Oy, image: Tietoa Visualisointi.

4.2.1 Interface between modeling and the decision-making process

At this stage, the Client's tasks include overseeing the design, comparing the alternatives, and selecting the best design solution for the next stage in cooperation with the future end user of the building.

Guideline

Three-dimensional modeling and visualization facilitate the comparison between different alternatives and bring the design solutions to a concrete level. In addition to investment costs, life-cycle costs and environmental impact should also be included in the assessment. Comparison of proposed design solutions using simulations is one of the principal benefits of integrated models. Comprehensive comparisons performed at an early stage are important because even radical changes can still be easily made when discussing the general outlines of the project. The later the potential problems emerge in the process, the more difficult it is to resolve them without a major impact on cost or quality.

4.2.2 BIM of the Site and Existing Buildings

For new constructions, the construction site, and for renovation projects, also the modeling of existing building (Inventory BIM) are included in the BIM requirements because the modeling of the existing situation is a basic precondition for the design process and all further modeling.

Guideline

Depending on the construction site, the model of the site may be obtained from the basic municipal registers or commissioned from an external supplier. In renovation projects, the modeling of existing buildings can be performed on the basis of old documents or electronic measurements, depending on the required level of accuracy. The model for both the site and the existing buildings can be commissioned as a separate assignment from a measurement service company or an architectural design office.

The requirements concerning the BIM of the construction site and existing building are presented in Series 2 of the BIM requirements, “Modeling of the Starting Situation.”

4.2.3 Alternative Spatial Group Models and Spatial Models

In the design alternatives stage, a number of alternative solutions are assessed. The architect models the building with space objects with an accuracy that is sufficient for the decision-making concerning spatial arrangements, massing and the outer shell.

The architect’s spatial model must be prepared such that space types and areas as well as the total volume of the building can be automatically obtained from it. The requirements concerning spatial group models and spatial models are described in more detail in Series 3 of the BIM requirements, “Architectural Design.”

Use of the Integrated BIM provides new opportunities for various types of study. When examination of the alternatives are connected to the interconnected whole, it is important to coordinate the explore options between different disciplines. For example, different façade solutions can be explored through investment costs, through the impact of the building energy consumption and through visual appearance using the BIM in various analyses and simulations.

4.2.4 Structural Design

Based on the architect’s design proposal, the structural engineer creates a preliminary Building Element BIM for the entire building and detailed Building Element BIM for the type structures.

Requirements of the models are described in more detail in the series 5 of the BIM requirements “Structural Design.”

4.2.5 HVAC Design

Building services designers develop the design proposal for the initial system models, which contains main systems paths, space-consuming channels and cable routes. Other HVAC models in this stage include service area models, model rooms in 3D, 2D sections and spatial reservations of technical rooms.

Requirements of the models are described in more detail in Series 4 of the BIM requirements “MEP Design.”

4.2.6 Cost Estimation based on Areas and Volumes

Cost estimation based on space areas and volumes will be prepared from the architect’s alternative BIMs on the basis of room categories (office, auditorium, toilet, etc.), which are to serve as a basis of comparison of the investment costs pertaining to design alternatives.

Cost estimation based on space areas and volumes is included in the mandatory tasks of the BIM-based process. It is discussed in more detail in Series 7 of the BIM requirements, “Quantity Take-off.” The calculation of quantities and costs can be performed internally by the Client, included in the tasks of a project consultant, or commissioned as separate consulting. This will be agreed upon on a project-specific basis.

4.2.7 Energy Consumption Simulation and Calculation of Lifecycle Costs

On the basis of areas and room categories, preliminary energy simulations and life-cycle cost estimates can be prepared from the architect’s alternative BIMs, which are to serve as a basis of comparison between alternatives.

Energy simulation and life-cycle cost calculations are included in the mandatory tasks of a BIM-based process. They can be included in the tasks of an HVAC designer or commissioned as separate consulting assignment. Energy simulation and life-cycle cost calculation are discussed in more detail in Series 9 and 10 of the BIM requirements, “Use of Models in MEP Analyses” and “Energy Analysis.”

4.2.8 Visualizations

Models are convenient for visualization purposes because they help to establish a shared understanding of the alternative design solutions between the shareholders. The required number and quality of visualizations will be defined in the call for tender and design agreements on a project-specific basis. However, it should be noted that even though the BIMs contain most of the source information needed

for visualization, they do not always enable the desired level of detail or rendering without additional effort. Therefore, the information content of the BIM required for visualization cannot be defined in advance but needs to be decided, at least partially, during the progress of the project so that the visualization is capable of providing the information required for decision-making.

In the design of alternatives stage, the use of rough mass models is sufficient for conventional projects. Visualization is discussed in more detail in Series 8 of the BIM requirements, “Use of Models for Visualization Purposes.”

4.2.9 Comparison and Decisions

The information about alternatives provided by BIMs is used in the decision-making process alongside traditional procedures at the discretion of Senate Properties. The design solutions often affect the original requirements. Changes to the requirements must be recorded in the requirement documentation so that project requirements remain up-to-date in accordance with the decisions made and so that the most current information is available for the next stage.

4.2.10 BIM Coordinator

At the beginning of the BIM work, the BIM coordinator should arrange a technical model compatibility test to ensure that the BIMs from different design disciplines are at the same coordinates and elevation. In practice, the architect creates some model components (e.g., basement floor, slab, wall, window, furniture), in the correct location of the out coming building, and sends the IFC model to other discipline. Each designer creates similarly a couple of components using the own design software tools so that when the IFC-models are combined, it can be fully verified, that everyone is using the same coordinate system and elevations.

Other tasks for the BIM coordinator at this stage are:

- To find out what kind of models are needed for different purposes and who is responsible in creating them.
- To update the schedule for BIM according to the design schedule and BIM objectives according to the overall situation.
- Ensure that the required BIMs have been made.
- Check the compatibility of the BIMs and the absence of conflicts between them according to the design situation.

4.3 Early Design

In the early design stage, the basic design solution that was selected in the design of alternatives stage and exists in the form of an architect’s BIM is developed further. The client’s requirements have been updated in the previous stage to conform to the decisions made. At the early design stage, the client’s tasks include overseeing the design and approving the design solution for the subsequent detailed design phase. The BIMs enable fast, illustrative and interactive visualization and analyses (for example, energy and conditions simulations, cost information), which support communication and decision-making.

The design models from each discipline should always be available to others, which is ensured by agreeing on a sufficiently frequent uploads to the project server. A suitable sequence at this stage could be for example linked to the design group meetings (i.e. one to four weeks).

The work of different disciplines should make progress concurrently. At this design stage, this also includes the fact that significant changes might be made to the design.

4.3.1 Architectural Models

The architect develops the selected design alternative into a Preliminary Building Element BIM. At the end of the early design stage, the BIM must contain, in addition to spaces, at least the following:

- Load-bearing structures: pillars, columns, slabs and walls
- Walls categorized according to main type (external walls, light partition wall, etc.)
- Windows and doors, although at this stage without type information

The accuracy of the model must be sufficient for generating the drawing required for applying a building permit. The required content is defined in more detail in Series 3 of the BIM requirements, “Architectural Design.”

4.3.2 Structural Models

At this stage, the structural designer must confirm the dimensions, requirements and impact on the work of other designers of the structural system. The structural model of the early design stage must fulfill the requirements defined in Series 5 of the BIM requirements, “Structural Design.” It must be possible to use the model in the integration of the design solutions.

4.3.3 HVAC Models

At this stage, the HVAC designer must confirm the spatial requirements of the systems and their impact on the work of other designers. The model must contain the spatial requirements of main ducts and machine rooms to the extent that the required spatial reservations and their effects on other designer’s work can be assessed. The requirements concerning the spatial reservation model are defined in more detail in Series 4 of the BIM requirements, “MEP Design”. It must be possible to use the model in the integration of the design solutions.

4.3.4 Electrical Models

The electrical designer must define space requirements for those parts and components of electrical, telephone and data communications systems that have impact on space allocation. The requirements concerning the spatial reservation model are defined in more detail in Series 4 of the BIM requirements, “HVAC Design”. It must be possible to use the model in the integration of the design solutions.

4.3.5 Visualizations

The opportunities for visualization and the accuracy of the models will naturally increase during the course of the process. However, the requirements applicable to the visualizations in the early design stage are mainly the same as those presented in section 4.2.8. If needed, more detailed visualizations may also be required for items regarded significant for decision-making. Further information is also available in Series 8 of the BIM requirements, “Use of Models for Visualization”.

4.3.6 Model Merging and Checking

The joint assessment of the models of different designers should be started in the early design phase if models are also generated by other designers apart from the architect. The BIM coordinator or Head Designer usually assumes the responsibility for model merging, but it can be allocated to another party as agreed upon on a project-specific basis.

Guideline

Visual clash detections are performed at this point on the merged model concerning the spatial reservations of at least structures and systems. This makes it possible to verify that the systems and structures are in principle compatible and that the spatial reservations required for structures and systems have been taken into account in the architectural design. Other checking may also be performed on merged models depending on the nature and degree of complexity of the project.

Checking to ensure that the models are error-free is essential for the approval of the design solutions and for the further activities of the project. The purpose of the checking is to ensure that the content and structure of the models correspond with the BIM requirements. At the same time, the quality of the design solutions and the reliability of quantities data are also ensured.

4.3.7 Early Design Cost Estimation

Cost estimation based on space areas and volumes supplemented by preliminary building elements, must be prepared using the early design stage models. The cost estimation based on space areas and volumes prepared of the architect’s model on the basis of room categories (office room, lobby room, sanitary facilities...) supplemented by the quantities data obtained from the architect’s building element schedules and possibly also from those of other designers. Model-based quantity take-off is discussed in more detail in Series 7 of the BIM requirements, “Quantity Take-off.”

4.3.8 Energy Consumption Simulation and Calculation of Lifecycle Costs

On the basis of room categories (office room, lobby room, sanitary facilities...) and areas, preliminary energy simulations can be prepared from the architect's model, which will be supplemented by the building outer shell data. These include, for example, the characteristics of external walls and the areas and type information of windows to the extent they are known at this stage.

Energy simulation and life-cycle cost calculations are included in the mandatory tasks of a BIM-based process. The commissioning of these tasks will be decided on a project-specific basis, and they can be included in the tasks of an HVAC engineer or commissioned as separate consulting assignment. Energy simulation and life-cycle cost calculation are discussed in more detail in Series 9 and 10 of the BIM requirements, "Use of Models in MEP Analyses" and "Energy Analysis."

4.3.9 BIM Coordinator

As the design progresses, it is possible to obtain useful information from BIMs such as volumes and surface areas. The visual properties of the three-dimensional model are increasing, and design errors are easier to recognize, thereby enabling the Head Designer to ensure the non-contradiction of designs. The model can be used to compare the elevations of the ground and the building and to study the accessibility of the design solutions. The BIM coordinators responsibilities are roughly the same as those in the design of alternatives stage:

- To update the schedule for BIM according to the design schedule and BIM objectives according to the overall situation.
- Ensure that the required BIMs have been made.
- Check the compatibility of the BIMs and the absence of conflicts between them according to the design situation.

4.4 Detailed Design

The procedure for the detailed design stage is similar to that of the early design stage with the exception that the level of accuracy for the generated information is significantly raised. Design solutions will be finalized to a level of accuracy that is required for calls for tenders, and all models prepared for the project will be further specified using detailed type information. However, a substantial part of the detailed design stage information still needs to be generated in the form of traditional design documents. The information content and accuracy level of the models are defined in Series 3–5 of the domain-specific BIM instructions.

4.4.1 Impact of the BIM on Process and Decision-making

At the detailed design stage, the Client's tasks include overseeing the design and approving the design solutions. The visualizations and analyses enabled by the BIMs provide support for communication and decision-making. At the end of this stage, the detailed design solutions will be approved to the extent that they can be used for advancing to the tendering stage. In line with traditional design practice, the design will be supplemented during the construction stage. All BIMs must then be updated to reflect the changes made to the design solutions.

4.4.2 Architectural Models

Upon completion of the detailed design stage, the architect's model must be a so called Building Element BIM that contains the building elements in the form they are intended to be implemented. The actual model need not be dimensioned, but it must be dimensionally accurate in accordance with the BIM instructions (section 0). The required content is defined in more detail in Series 3 of the BIM requirements, "Architectural Design." It must be possible to use the model for quantity take-off and in the integration of the design solutions.

4.4.3 Structural Models

The structural designer's documents must correspond with the architectural model and it must fulfill the requirements defined in Series 5 of the BIM requirements, "Structural Design." It must be possible to use the model for quantity take-off and in the integration of the design solutions.

4.4.4 HVAC Models

The HVAC designer's documents must correspond with the architectural model. The modeling in this stage will focus on the creation of a system model. It must fulfill the requirements defined in Series 4 of the BIM requirements, "MEP Design." It must be possible to use the model in the quantity take-off and in the integration of the design solutions.

4.4.5 Electrical Models

The electrical designer's documents must correspond with the architectural model. The modeling in this stage will focus on the creation of a system model. It must fulfill the requirements defined in Series 4 of the BIM requirements, "MEP Design". It must be possible to use the model in the quantity take-off and in the integration of the design solutions.

4.4.6 Visualizations

The BIM must be used for visualizing the design solutions. The required number and quality of visualizations will be defined in the call for tender and design agreements on a project-specific basis. However, it should be noted that even though the BIMs contain most of the source information needed for visualization, they do not always enable reaching the desired end result without additional effort. Therefore, the information content of the BIM required for visualization cannot be defined in advance but needs to be decided, at least partially, during the progress of the project so that the visualization is capable of providing the information needed for decision-making.

In the detailed design stage, the opportunities for visualization are substantially better than in the previous stages, because the information contained in the model is often sufficient for a visualization of a notably high quality. Visualization is discussed in more detail in Series 8 of the BIM requirements, "Use of Models for Visualization".

4.4.7 Model Merging and Checking

Merged models are created from the models of individual designers during the project, and it can be used for visualizing the designs and assessing their compatibility. The assessments performed at this stage include, e.g., the clash detections of the HVAC systems, clash detections of systems and structures, verification of the sufficiency of the spaces reserved for systems, and penetration and reservation design. These merged models are discussed in Series 4 "MEP design", 5 "Structural design" and 6 "Quality assurance and merging of models" of the BIM requirements.

At the official decision points, all generated models will be checked as specified in Series 6 of the BIM requirements, "Quality assurance and merging of models".

4.4.8 Cost Estimation and Bills of Quantities

Bills of quantities and cost estimates based on them will be prepared on the basis of the checked BIMs. The bills of quantities will also be used in the contract tendering stage.

The bills of quantities and cost estimates generated from the BIMs can be included in the mandatory tasks of a BIM-based process. They can be performed by the Client, included in the tasks of a project consultant, or commissioned as separate consulting. This will be agreed upon on a project-specific basis.

In addition to BIM-based bills of quantities, it will be necessary to also survey quantities by traditional methods, because modeling is not, at least currently, not capable of covering all of the required information. Further details are provided in Series 7 of the BIM requirements, "Quantity take-off".

4.4.9 Energy Consumption Simulation and Calculation of Lifecycle Costs

On the basis of the detailed design information, the models prepared in the detailed design stage can be used for generating the final energy simulations and life-cycle cost calculations, which can then be compared with the actual costs during the occupancy of the building.

Energy simulation and life-cycle cost calculation are discussed in more detail in Series 9 "Use of models in MEP analyses" and Series 10 "Energy Analysis." They are included in the mandatory tasks of a BIM-based process and they can be included in the tasks of an HVAC engineer or commissioned as separate consulting assignment.

4.4.10 BIM Coordinator

In BIM based design, many Clients stress specifically an error free construction. The Head Designer is responsible for ensuring that the designs don't have conflicts and that construction work can be done according to them. The BIM coordinator will support the Head Designer and other disciplines to achieve this goal. In other respects, the BIM coordinator duties follow the pattern from the previous design stages:

- To update the schedule for BIM according to the design schedule and BIM objectives according to the overall situation.
- Ensure that the required BIMs have been made.
- Check the compatibility of the BIMs and the absence of conflicts between them according to the design situation.

4.5 Contract Tendering Stage

At the contract tendering stage, the BIMs and the bills of quantities, visualizations and other documents generated from them will be handed over to the contractors for the purpose of facilitating the preparation of tenders and preliminary planning of the construction work.

4.5.1 Analysis and Planning

With the help of three-dimensional BIMs, visualizations and other information obtained from the models, the contractors are better able to familiarize themselves with the design plans and the construction site. The tenders must be based on the quantities presented in the original call for tender.

Guideline

There are 4D software applications available for work planning and scheduling with which different schedule and implementation options can be tested. The use of models is at the discretion of the contractor.

It must, however, be considered that the use of BIM on-site may require special ways of modeling, and therefore needs to be agreed as early in the project as possible. If BIMs are used in scheduling and work planning, it is essential that the building parts and products in the model, as well as their grouping should be consistent with the actual situation on site. If the models are to be used, for example, in scheduling, the method should be known by the designers as early as possible, so that the model can be drawn up accordingly.

4.6 Construction

4.6.1 Using BIM in Construction

Most uses of BIMs by the contractors, is related to organizing the production processes. This section is a brief description of the main uses of the models. More detailed description can be found in the Series 13 "Use of Models in Construction."

The 3D visual nature of BIMs is a significant benefit of models in many different situations. Models are a good way to study the designs and structures and to plan installation procedures and coordination of the work.

The BIM based quantity take-offs speed up the calculation process and gives a more accurate result, assuming that the modeling is done properly and without error. Model-based quantity take-off and report templates reduce a significant amount of duplicated work, which improves the productivity of construction.

It is already certain that BIMs and different types of reports that are generated from BIMs will be used as tender documentation for subcontracts. Subcontracts may also include additional BIM based design.

The BIM based schedule is intended to complement the construction schedule which is given to the Client and to give, for example, a visual control over the installation order of systems. Critical structures, for example, the foundations, the load bearing core, and demolition work, may be presented with the help of the model.

The ongoing construction work can be stored in the model daily or weekly in order to illustrate and document the progress of the construction and installation work.

Contractors and designers can use BIM to study the installation of prefab and in-situ cast structures, installation order of different building services systems, temporary supports etc. If all temporary supports and structures are also modeled, the model can help to study the security and logistical issues for them as well.

The site can utilize the BIMs also in meetings for HVAC installations, in which the work sections and installation order are studied with contractors in order to ensure the schedule compatibility among the various contractors.

4.7 Commissioning

From the point of view of modeling, the most important documents generated at this stage are the As-built Models and the maintenance manual. The maintenance manuals, however, are not generally required in a BIM-based format.

4.7.1 Using BIMs in Maintenance

BIM-based maintenance manuals are currently in a developmental stage and are thus only required in exceptional cases. However, regardless of the working methods, all parties must fulfill normal documentation requirements of the Client concerning maintenance manuals.

Further details are provided in Series 12 of the BIM requirements, "Use of Models in Facility Management."

4.7.2 As-built Models

All BIMs required for the project must be supplemented in the construction stage to reflect the modifications made so that they correspond with the end result 'as-built.' The requirements concerning information content are similar to those in the detailed design stage and applicable to all parties; see Series 3 "Architectural Design," Series 4, "MEP Design," and Series 5, "Structural Design" of the BIM requirements.

However, in the calls for tenders concerning construction and design it is possible to declare that as-built models are also required from contractors. The primary intended use of As-built Models relates to the use, maintenance and repair of the building. As-built Models are agreed upon on a case-specific basis.

Appendix 1: General Purposes of BIM in Different Phases of the Project

ARCHITECTURAL DESIGN	STRUCTURAL DESIGN	MEP DESIGN	
Requirements BIM	Requirements BIM	Requirements BIM	
Space program in a spreadsheet format, requirements of the client and the end-user	Space-specific loads and other structural requirements, if any	MEP requirements for the spaces (indoor climate, lighting, system requirements, etc.)	- Documentation of space requirements and possible other requirements in a structured form
Site BIM			
Site borders, elevations, required joining to the surroundings and to the			- Site use planning - Location of the building(s) on the site
Inventory BIM	Inventory BIM	Inventory BIM	
Spaces and building elements of the existing building(s)	Load-bearing structures, typically included in the architectural BIM	MEP systems to the extent regarded applicable	- Documentation of the starting situation for renovation construction
Spatial Group BIM			
Special case of Spatial BIM. Building masses and principal spatial groups are presented as space objects.			- Investigation and visualization of the building's massing as well as comparison between alternatives - Investment calculation based on scope and massing - Rough energy simulation if applicable
Spatial BIM	Spatial Reservation BIM	Spatial Reservation BIM	
Spaces as space objects, building envelope	Suggestion for structural system, suggestion for basic structure	MEP system service areas, main ducts and flues, as well as pipework, cable racks and other technical systems and spaces presenting significant space requirements	- Design and visualization of alternative spatial design solutions - Scope management - Investment calculation - Energy simulation and, if required, simulation of ambient conditions (determining the dimensioning bases for systems) - Examining MEP system alternatives and determining service areas - Examining structural system alternatives - Agreements concerning spatial requirements for structures and systems
Building Element and System BIMs			
Building Element and System models are an integral part of project planning and management of information. In BIM-based process the content of the models equals designs. Also the aimed use of the BIMs reflects to the contents of the models.			
Preliminary Building Element BIM	Preliminary Building Element BIM	Preliminary System BIM	
Spaces, preliminary building elements	Frame structures (measures, locations and dimensions of the vertical and horizontal frame), agreed BIM details, foundations	Service areas of MEP systems, main ducts, pipework and central units	- Definition of building elements, comparison of building element and structural alternatives - Management of quantity information - Investment calculation - Energy simulation and, if required, simulation of ambient conditions (further specification of the dimensioning bases for systems) - Preliminary dimensioning of structures - Building permit
Building Element BIM Quantity take-off phase	Penetration and Reservation BIM Quantity take-off phase	Penetration and Reservation BIM Quantity take-off phase	
Tilat, rakennusosat tyypitetöineen	Frame structures (measures, locations and dimensions of the vertical and horizontal frame, example elements, type structures and joints, foundations), joinings to foundations, penetrations and reservations	Service areas of MEP systems, central units, ducts, pipework, terminal devices, switchboards, cable routes (lead and cable-throughs and grates), lighting fixtures, penetrations and reservations	- Dimensioning of structures to the precision required in the calls for tenders - Definition of MEP systems - Quantity take-off - Investment calculation - Energy simulation - Use of models as appendices to tenders - Use of models to support penetration and reservation design
Building Element BIM Construction phase	Building Element BIM Construction phase	System BIM Construction phase	
BIM with a level of precision similar to that of the previous stage, updated to correspond with the implementation	Frame structures and joints, input information to prefabricated element design, placements and reinforcements of cast-in-situ structures, foundations, joinings to foundations, details, penetrations and reservations	Service areas of MEP systems, central units, ducts, pipework, terminal devices, switchboards, cable routes (lead and cable-throughs and grates), lighting fixtures, penetrations and reservations	- Detailed design - Information for prefabricated element design and production planning
As-built model	As-built model	As-built model	
BIM with a level of precision similar to that of the previous stage, updated to correspond with the final implementation	BIM with a level of precision similar to that of the previous stage, updated to correspond with the final implementation	BIM with a level of precision similar to that of the previous stage, updated to correspond with the final implementation	- Information to maintenance and repairs, space and occupancy management and to the planning of later use and renovation of the building