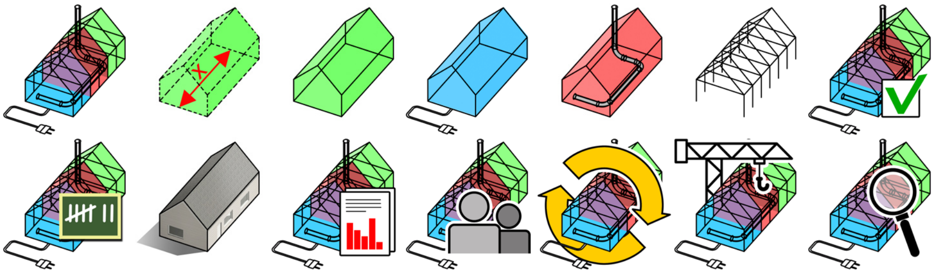
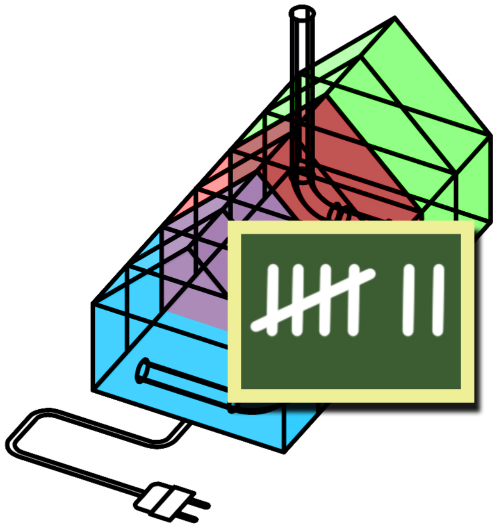


COBIM

Common BIM Requirements 2012

v 1.0



Series 7

Quantity take-off

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 parties to the project have a need to define more precisely than before 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 on model-based operations.

The parties to 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. **Written by:** Finnmap Consulting Oy, Gravicon Oy, Olof Granlund Oy, Lemminkäinen Talo Oy, NCC companies, Pöyry CM Oy, Skanska Oyj/VTT Technical Research Centre of Finland, Solibri, Inc., SRV Rakennus Oy, Tietoa Finland Oy. **Management:** The Building Information Foundation RTS.

The requirements were approved by an executive group consisting of parties to the project. 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.

Section 7 compiled by Finnmap Consulting Oy, Matti Tauriainen

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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 life cycle, starting from initial design and continuing even during use and facility management (FM) after the construction project has concluded.

Data models enable the following, for example:

- Provision of support to the 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.
- The enhancement of quality-assurance and data-transfer and making the design process more effective.
- The utilization of building project data during use and facility management activities.

To make modeling successful, project-specific focal points and objectives must be set for models and model utilization. Project-specific requirements will 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 consolidation 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 life-cycle 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 where 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.

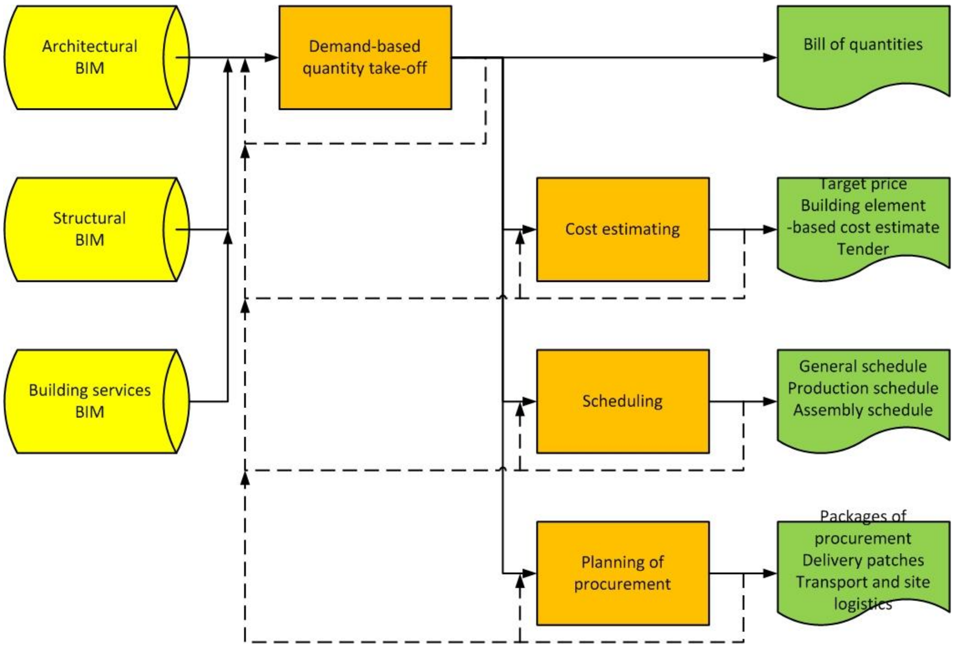
The publication series “Common BIM Requirements 2012” consists of the following documents:

1. General part
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 in his or her field, each party to a building information modeling project must be acquainted at a minimum with the general part (Section 1) and the principles of quality assurance (Section 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

Through the utilization of building information models (BIM) it is possible to make quantity take-off considerably more effective, and to increase the utilization of quantity data in different decision-making situations. Measuring quantities manually from drawings is replaced by computer-assisted measurement from a BIM. Quantities can be measured from architectural, structural and building services technology data models and their integrations. It is possible for building owners and clients, designers, contractors and product fabricators to utilize quantity take-off in completely new ways and from new perspectives.



BIM-based operations change the work of the quantity surveyor significantly – the amount of routine tasks decreases while professional skill requirements increase. The quantity surveyor is noticeably becoming a quantity specialist.

However, a BIM does not resolve quantity take-off related issues “exhaustively” and not all quantities needed during a project can be taken off from a BIM. The professional skill of a quantity specialist is still needed for assessing the validity of the source data and source materials, ensuring the coverage of the take-off, proposing alternative solutions and analyzing the results.

This document does not contain instructions for how quantities must be taken off from a BIM. The purpose of these guidelines is to provide the reader with an understanding of what is meant by BIM-based quantity take-off. The guidelines address only the take-off of quantities from a BIM, and not, for example, the utilization of the quantities in investment and life-cycle cost accounting, assessment of environmental effects, scheduling and the activities of different operators within the construction industry. No views are expressed in this document with regard to commercial software tools used in quantity take-off.

3 Quantity take-off related requirements for building information models

3.1 Consistency of modeling

Requirements
From the perspective of quantity take-off, the most important attribute of a model is consistency: all building and building services elements are modeled according to BIM requirements and the modeling method used is documented in the BIM specification.

Guideline
Difficulties arise in situations where the design solution is not modeled according to requirements, and in addition, the modeling was done differently in different parts of the same model.

However, the model may contain building elements that are modeled to a different level of detail than other elements of the same model, for example when a building element is first "experimented with" in one section of the building only. Another example is a model where only type elments are modeled to a detailed level, while other elements contain only the geometric information of the structure. The designer records such situations in the BIM specification and the quantity specialist must take them into consideration in quantity take-off.

3.2 Level of detail of the BIM

Requirements
The level of detail (LoD) of BIM is defined when an order is placed for the modeling. Levels of details are described in the modeling requirements for different design disciplines.

Guideline
The level of detail of the BIM determines the level of accuracy of the quantities taken off from it. When the architectural, structural and building services models are modeled to the same level of detail throughout the building, the situation is clear in terms of quantity measurement and the quatities can be assessed unequivocally relative to the model's level of detail.

The design phase, and how designing progresses, define the model's level of detail. The contents of BIM are augmented as each design phase is completed. In quantity take-off, the principle of calculating quantities in phases on the basis of the model whose information content is the most precise, accurate and inclusive can be considered a general guideline.

In some cases, it is sensible to model one part of the building to a greater level of detail than other parts, or to transfer the agreed-upon alterations first into a part of the model only. This allows quantity take-off from the more detailed or updated part of the model, and then use of factors to calculate the quantities of the whole building. For example, in a five-story building, partition walls could be modeled initially for one floor only, and a factor of 5 could be used to calculate the total quantity of partition walls.

If modeling progresses at different levels of detail in different sections of building, it is very important that a more detailed modeling or updating is carried out according section borders. The rule must also be clearly recorded in the BIM specification so that the quantity specialist can utilize the model in the correct way.

3.3 Using BIM tools

Requirements
In terms of quantity take-off, it is of utmost importance to use modeling tools that enable the production of the measurement information required for quantity take-off. This requirement is best met when a building element is modeled using the modeling tool that is intended for the element, for example when walls are modeled using a wall tool.

Guideline
If a tool that is incompatible with quantity take-off purposes was used for modeling a building element, the quantities for that element cannot be taken off automatically. Such situations may be encountered when the designer's software does not include a separate tool for the building element to be modeled, for example, when architectural or structural design tools are used to model the structures in site areas. Problem situations typically occurring in quantity take-off are addressed in Chapter 6.

3.4 Identifying building and building services elements

Requirements
From the perspective of quantity take-off, the spaces and building elements and building services parts must be identifiable individually. For example, the structural type of the walls or the ventilation duct type must be identified because total quantities are calculated by adding up single quantities.

Guideline
Structural type is the clearest identification information of building elements, although identification can also be done on the basis of any information pertaining to the building element, such as wall height. For example, wooden walls of different height which from the architect's perspective are of the same type may from the perspective of construction be of a different structural type, in which case they are, from the perspective of quantity take-off, of a different type.

3.5 Essential measurement information

Guideline
In conventional quantity take-off, simplified measurements are frequently used, for example, using projection surface area instead of the actual surface area. Building elements' quantity data can be derived from the model according to the situation that corresponds to modeling principles.

The following measurement information is commonly used in quantity take-off:

- *Number of pieces*
- *Measure of length*
    - *Length*

    - *Perimeter*
    - *Height*
- *Area measure*
    - *Net surface area*
    - *Gross surface area*
- *Volume measures*
    - *Net volume*
    - *Gross volume*
- *Weight*
    - *Net weight*
    - *Gross weight*

3.6 Use of software tools and data transfer

Guideline

The information exchange solution used in the project and the software application used for quantity take-off, impact the quantity and measurement information available for use by the quantity surveyor. They also affect the reliability of the information. In quantity take-off, the BIM can be used either in its native file format or in the IFC file format. The information content of BIM is most complete in the native file format of the BIM. It is recommended that the native model created by the designer is used for quantity take-off, if available.

When an IFC-type file is used in quantity take-off, the quantity surveyor must ascertain which building elements have been exported into the IFC file from the native file, and how the software tool used in quantity take-off is capable of processing the building objects contained in the IFC file. The model must always be accompanied by a BIM specification entailing the fundamental coverage of the model's information content and the model's purpose of use.

4 Model-based quantity take-off methods and connecting them to project management, decision making and modeling phases

Because of its effectiveness, model-based quantity take-off allows for conducting the take-off more frequently than a quantity take-off completed by conventional methods. It also offers the opportunity to explore more alternatives. Changes in quantities occurring during the design and construction phases can also be analyzed, visualized and reported in a reliable manner. The frequency of conducting a quantity take-off and how many alternatives are explored will of course be decided according to project needs.

The BIM documentation used in quantity take-off contains models, BIM specification and in many cases, the construction specification. BIM documentation can be complemented by other documentation and information vital in terms of quantity take-off (such as drawings and lists).

Requirements
The quality of the models, to be submitted for use in quantity take-off, is inspected and clash checked before they are submitted to quantity-take off. They must not contain overlapping building parts. The model's inspection report is attached to the BIM specification.

4.1 Key concepts of quantity take-off

Requirements
Use of nomenclature must be agreed upon on a project-specific basis.

When nomenclature is used, types of building and building services elements are specified by means of a public or project- or company-specific type identifier. For example, when Talo 2000 project nomenclature is used, the specification is as follows:

Nomenclature item	Element type identification	Description
1232 Bearing walls	VS401	Reinforced concrete wall 180 mm
1241 External walls	US409	Sandwich wall, tile cladding 320 mm

Guideline
Building and building services elements describe the building as a physical entity. A building element is a conceptually independent object of a building viewed as a completed entity. ***Building elements*** *consist of construction products. A* ***building services element*** *is a conceptually independent material part or product of the building services system viewed as a completed entity. Building services elements consist of building services products. A* ***construction***

product *is a commodity used for construction that remains as a permanent part of the building or is used completely during construction. In quantity take-off, building and building services elements are divided into* ***products*** *(trade names) for which the quantities are calculated. Building and building services elements are itemized and measured by each building part according to the nomenclature. Nomenclature is used if agreed upon on a project-specific basis.*

The following are the most important nomenclatures used in construction engineering (in Finland):

Talo 2000 project nomenclature

Talo 2000 production nomenclature

Talo 2000 construction product nomenclature

HVAC 2010 nomenclature

S2010 electrical nomenclature

A list and structure are also among the key concepts of quantity take-off. ***List*** *itemizes building details included in the design, for example, spaces, building elements and construction products, or tasks and acquisitions. A list entailing quantities is a bill of quantities. Generally speaking,* ***structure*** *exists between two nomenclature levels, and uses the subordinate level to describe the amount of products and materials used of one unit of the higher level. In practice, this is the product structure of a building element that consists of several construction products.*

In model-based quantity take-off, the information of list and structure are derived from the BIM objects, and information become more accurate as the project progresses. Frequently, the information of list and structure must be augmented during quantity take-off by means of adding design and specification information.

4.2 Main levels of utilizing model data in quantity take-off

Guideline

With regard to quantity take-off, model information content can be divided into building and building services elements, nomenclature items and product and product-structure quantities. When taking off building and building services elements, the elements reported on the basis of BIM contain the information defined by the designer, organized by element types, for example. The quantity report is produced as a bill of quantitie,s using the basic reporting tools of design software or, for example, by exporting data from an IFC file into Excel.

In take-off based on nomenclature item quantities, building and services elements are taken off according to nomenclature items. In that instance, the quantities of the external wall type, which the designer has designated as "US409", will be assigned the name 1241"Ulkoseinät", External walls. Several element types can be combined to form one nomenclature item, or several nomenclature items and take-off quantities can be formed based on one element type.

In take-off based on quantities of product structures, the product structure describes specifically the building element. Product structure is used, for example, for calculating a resource-based cost estimates. Product structure is also used in production scheduling the duration of tasks. Product structures can also be used as the basis for different types of procurement packages.

If the resource-structures used in cost estimating and scheduling are "tuned to rectify" the simplifications of quantity measurement, the rules for taking off product structures must be developed to suit model-based take-off in the quantity surveyor's own activities.

4.3 Quantity take-off during the design phase

4.3.1 Key figure take-off

Requirements
Basic key figures, such as the building's gross area, volume and facade surface area are taken off from the BIM.

Guideline
The basic key figures are used to form derived figures, for example, the relationship of the total volume of the building to the facade surface area. Derived figures are used to examine the effectiveness of the design solution, for example. An architectural-design space model or building element model is needed for the take off of basic key figures.

Identification numbers can also be taken off, for example, from structural frame or building services systems on a building-element-specific basis. For example, preliminary quantities of structural frame elements or numbers of water and sewer points can be estimated. In that case, design-discipline-specific BIMs are used for take-off.

4.3.2 Space-based take-off

Requirements
The areas of programmed spaces, and also as needed, spaces outside the space program, are extracted from the BIM and summed up by space type in a space list.

Guideline
The space list can be compared against the space program, used in estimating and setting a target price, and also in guiding design to reach the objectives set by the developer. Space-based take-off is also used in estimating the room areas of spaces to be rented and/or sold.

An architectural-design space BIM is needed for space-based take-off.

4.3.3 Preliminary building element take-off

Requirements

Quantities are taken off from the BIM based on the building and building services elements in the BIM; for example these include quantities of load-bearing walls and different intermediate floors or central components of ventilation service areas, such as supply air and exhaust air terminal devices.

Guideline
The quantities taken off form a traditional building element bill of quantities. The bill of quantities can be utilized to determine changes in quantities and estimate costs to control design, and also in evaluating the preliminary construction schedule and production solutions.

An architectural-design preliminary building element model and building services preliminary model and service area diagrams are a minimum requirement for preliminary building-part take-off. The quantity surveyor uses the information of building elments and element types to form presumptions of the more precise types and quantities of building parts. The objects in the model are building elements, for example, a wall is modeled as one object instead of modeling each structural layer of the wall separately. In the building element model, the more precise type information can be found, and as a result, the quantity surveyor makes fewer presumptions.

4.3.4 Enhanced building element take-off

Requirements
The quantities of building elements are extracted from the BIM on the basis of the building and building services elements the model contains.

Guideline
In this phase, the architectural-design building element model, structural-design general planning phase structural model or the procurement phase structural model, and possibly also building services system model are usually available for use. Compared to preliminary building element take-off, the quantities of building and services elements are made more specific by means of product structures and information contents. In the architect's BIM, the structural layers of building element can be itemized. In the structural model, structural types are specified.

With regard to building elements, product structures and building services systems, the model level of detail has been augmented compared to the level of detail in the preliminary building-part model.

4.4 Take-off during the tendering and construction phase

4.4.1 Performance and resource-based take-off

Requirements
Performance and resource-based take-off is based on complete product structures.

Guideline
Architectural-design building element model, building-services system model, structural design procurement phase model and construction phase model are available for use. Quantities of building and building services elements, including product structures, are taken off from the model according to the project or production nomenclature for the purpose of defining construction tasks. For example, the quantity of footing reinforcement can either be derived from the cubic content (kg/m3) of the object representing the footing, or taken off from the reinforcement object inside the model.

The requirements set for the model are the same as in enhanced building element take-off. However, performance or resource-based take-off is generally used in the procurement and construction phase for developing different types of offers and orders and planning production tasks and scheduling.

Product structures presented in different BIMs; see Appendix 1.

4.4.2 Quantity take-off by location

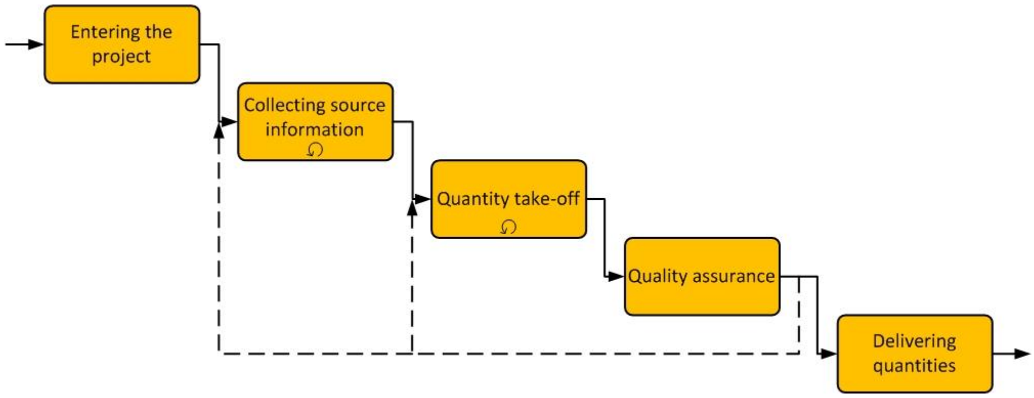
Requirements
Quantities are taken off from the model by using one of the above-mentioned methods; quantities are organized by location.

Guideline
Locations that are used often include sub-project, section, building story, space group or zone and space. Quantity take-off by location is typically used for taking off procurement quantities and input information for scheduling.

The minimum requirements for the model are the same as for building element take-off; in addition locations must be modeled. Assigning building elements to the above-mentioned locations may require different types of additional measures, depending on the software application used, even though all the objects in the model have a geometric location inside the model.

5 The quantity take-off process

The BIM based process for quantity take-off is in many ways different from the traditional document based quantity take-off process. The following introduces a process that creates the conditions for successful model-based quantity take-off.



5.1 Entering the project

Entering the project is done once before the first quantity calculation. Through a BIM the scope and other characteristics of the project and design are easier to comprehend. In addition to the BIM, it is advisable to study other relevant material, such as the building specification, and to discuss the design with the designers.

5.2 Collecting source information

Requirements
Before each time quantities are taken off, the source information for quantity take-off must be collected. It must also be verified that the quantity surveyor has the correct version of each relevant file.

Matters to be agreed upon on a project-specific basis:

- It must be determined, if quantity take-off is done from the models of one design discipline or several. If models from several disciplines are used, it must be determined which quantities are taken off from each of the models. For example, if the load-bearing structures are taken off from the structural designers BIM and doors and windows from the architect’s BIM.
- It must be determined, if the BIM of some design discipline is divided into several partial BIMs.
- It must be determined, if the take-off should be done from original BIM or from an IFC file produced from it.
- If the take-off is done from the designer’s original BIM, it must be ensured that the delivered material contains all necessary library elements and external references and the model can be opened without problems in the software application used by the quantity surveyor.

- The scope of quantities to be taken off the model must be determined, i.e. which quantities can be taken off the model ands which have to be taken off using other methods.
- It must be determined, if the whole BIM is modeled to the same level of detail, and if quantities are to be taken off the whole model or only part of it. The BIM may, for example, contain building and building services elements, spaces, equipment and furniture that are outside quantity-take off. In such cases, it must be determined, if the model objects included in the take-off and those excluded from it can be identified, for example by means of naming codes, visualizations and/or a layer combination. Information about the modeling principles can be found in the BIM specification created by the author of the BIM.
- With regard to the building specification, it must be determined, if its information is consistent with the BIM, for example, that both use the same structural types. All changes that have been agreed upon must be captured in the building specification, because it cannot be expected that the quantity surveyor collects such information from, for example, the minutes of design meetings.
- The main changes made to the BIMs and the building specifications compared to the preceding versions used for quantity take-off must be determined.

Guideline

Any shortcomings of the BIM and related material are mainly caught during the quality assurance process and documented in the BIM inspection report, which the quality surveyor should thoroughly peruse. Resolving any internal conflicts of the source material and notifying the team of them is the responsibility of the principal designer or other person appointed by the client. Shortcomings can be accepted as long as the quantity surveyor is aware of them before the take-off is started. The quantity surveyor may also express an opinion as to whether conducting a take-off with the intended scope is meaningful on the basis of the source material provided. If there are too many shortcomings, postponing the quantity take-off to a later date may be considered.

The version management of the quantity take-off source material is the responsibility of the designers and the principal designer. It must be safe for the quantity surveyor to assume that the delivered material contains the correct versions of all files. This is ensured by each designer being responsible for versioning their own files, while the principal designer or another person appointed by the client is responsible for collecting, versioning and publishing the file package delivered to quantity take-off. However, the quantity surveyor must always notify a representative of the client, if there is any doubt about having the correct versions of all files.

5.3 Quantity take-off; conducting the take-off

Requirements

BIM-based quantity take-off is done using a suitable software application.

Guideline

The capabilities of the software application used have a decisive impact on the reliability and efficiency of the take-off process, for example, when a new version of the model is delivered to take-off, or the task is to conduct several alternative take-offs from the same model.

5.3.1 Guided, automated identification and quantity take-off

Guideline
BIM content and building elements can be identified and grouped in an automated manner so, that the measurement information needed for quantity take-off can be read from BIM objects. This option utilizes the BIM in the best possible way. Quantities can be taken off efficiently and reliably and visualized using the model. The quantity surveyor does not need to modify the model, making quantity updating by means of the new version of the model effective.

5.3.2 Quantity derivation and on-screen take-off

Guideline
The BIM does not as such contain the information needed for quantity take-off, but this information can be derived from other building elements included in the model. For example, the length of the footings can be taken off quite accurately using the length of the load-bearing walls of the bottom-most floor. The quantity surveyor does not need to modify the model, making quantity updating by means of the new version of the model effective.

5.3.3 Augmenting the model

Guideline
The BIM as such does not contain the information needed for quantity take-off, but the quantity surveyor can model this information based on the other building elements within the model. For example, a rain gutter can be modeled to the edge of the roof using the wall tool. After that, the quantities assigned to the eaves structures can be calculated quite reliably and relatively quickly. Quantities can also be visualized using the model. This procedure entails the following problems, among others: in effecting the model change, the wrong tool is used and consequently, the quantity surveyor loses the model changes he or she has made when updating the new verion of model in quantity take-off, unless the designer has incorporated the corresponding changes into the model.

5.4 Quality assurance and delivery of quantities

Guideline
After the quantity take-off has been completed, the results of the take-off are analyzed with regard to coverage, accuracy and reliability. With regard to coverage of the quantity take-off results, it should be verified that all the quantities included in the quantity take-off have been calculated. Building and building services elements included in the take-off are visualized into the model for the purpose of quantity take-off coverage assessment. The visualization is compared to the drawings, for example.

In order to assess the accuracy of the take-off according nomenclature items, the quantitiesincluded in the take-off are checked, for example by means of comparison of key and entered figures against a reference target. When *necessary, a nomenclature item comparison take-off is also conducted from the BIM in another file format or drawings. The reliability of the calculation is assessed relative to the source information and the take-off methods used, and also the presumptions and augmentations made on the basis other take-off materials.*

The final result of quantity take-off is a bill of quantities which is delivered further to cost esitmating and for other use, and organized as per the client's wishes. The bill of quantities can be stored in several different file formats. BIM-based quantity take-off enables the visualization of quantities in new ways. In the design software or in between the design software and the quantity take-off software, quantities are linked dynamically to the BIM used in the take-off. This makes it possible to visualize, as needed, the model elemets used in calculating quantities.

It is important to note that all quantity take-off results are associated with the source information "file package" from which they were taken off. It is important that all bill of quantities derived from them are clearly associated with this package, because taken alone or associated with a different package they no longer provide correct information about the design solution.

6 Problems encountered in BIM-based quantity take-off

This chapter addresses typical problems associated with BIM-based quantity take-off. While the listing is not comprehensive in coverage, it does help in understanding what types of issues should be taken into consideration when taking off quantities from designers' models. In all cases, the minimum requirement for a BIM is the possibility to distinguish points that are reliable from those that are unreliable in terms of quantity take-off. When problematic cases are detected, they can be cleared up; only problems left undetected cause errors in the final take-off results.

6.1 Take-off from BIMs of several design disciplines

BIMs of different design disciplines (architectural, structural, building services, etc.) do overlap, even when executed correctly. The same load-bearing structures are found in the architect's BIM as in the structural designer's BIM, and terminal fittings (wash basins, lighting fixtures, etc.) of the building services system are often modeled in the architectural BIM. When models of several design disciplines are used as source information for quantity take-off, one must be cognizant of the overlaps and decide which model will be used for quantity take-off. As a rule, structural and building service technology models contain more accurate information on the building and system elements and terminal fittings than the architectural model, where said components are presented mostly as space reservation or placeholders.

6.2 Space surfaces

Many of the current architectural design software applications lack adequate tools for modeling space objects and surfaces. In most cases, space surfaces are not modeled as separate objects, and for that reasonthey are calculated on the basis of space objects. The accuracy produced in this way is adequate in the early phase of design; however, as design proceed in more precise level of detail partial surfaces in particular become problematic. Also, there is great variance in design software applications as to how they identify spaces to their bounding elements. For example, when two spaces are directly adjoined (there is no wall between them), some software tools produce a space surface also between the two spaces. Taking off floor surface areas may also be problematic, if the software application reports a surface area according to the program space area, instead of the actual space area.

6.3 Roofs

Design software applications contain tools that enable modeling multiform roofs as one entity. From the design perspective, this provides superior opportunities for managing and modifying roof shapes. From the point of view of quantity take-off, however, the situation is problematic because none of the measurement information needed for quantity take-off can be derived from the roof structures modeled in this way.

6.4 Stairs

When stairs are calculated as numbers of pieces, the present models are adequate. Problems can occur in the take-off of stair components, such as railings, landings, steps, etc. It must be ensured, that these components are modified for take-off before take-off is undertaken.

6.5 Curtain walls

Design software applications contain tools that allow curtain walls (light, non-load-bearing exterior walls) to be modeled as an entity. However, calculating the components of a curtain wall in a manner required by quantity take-off may be impossible because modeling software tools focus mainly on the geometry of curtain walls instead of their information content. Modeling curtain walls using wall, window and door tools is a better alternative in terms of quantity take-off.

6.6 Parametric parts of the model

Most software applications allow the user to develop user-defined objects; the software does not define or restrict the scope and content of objects in any way. These objects are parametric, i.e. they contain numerically defined characteristics which help produce several different instances of the same object. For example, the object, that presents a table, can contain adjustments for the length of the table, as well as for the number of table legs. In that case, the same object can be adjusted to represent a table that is 120 cm long and has four legs or a table 200 cm in length with six legs. Parametric objects can also represent extensive entities, such as bathrooms or even entire buildings.

With regard to quantity take-off, however, parametric objects are problematic on several different levels. Identifying even a simple type is difficult, because the name does not reveal its exact content, for example the dimensions or other characteristics of a table. More exact characteristics are found within the instance-specific characteristics of the relevant part.

With regard to quantity take-off, the most difficult cases are those that involve parametric objects representing large entities. For example, it may be impossible to take off the quantities of balconies and individual structural components from the parametric object that represents a balcony tower. In that instance, the only alternative is to either calculate the entity represented by that object manually or through the product structure.

With regard to quantity take-off, each parametric object must be examined separately. When the parametric object has been identified, the number of pieces of, for example, the columns and slabs in the balcony tower can be calculated. In many cases, the number of pieces is not sufficient as such, instead, lengths and slabs surface area, for example, must be used as quantity data. Parametric objects can be built such that they are capable of reporting lengths, surface areas, cubic contents, weights, etc. However, the reliability of such information is totally dependent on the object's author.

6.7 Special geometric cases

The unique shapes of buildings or solutions used are often vitally important in terms of quantity take-off and cost esitmation. These include, for example, curved and slanted building parts, and those containing unique openings, geometric insertions and extractions. In such cases, design software tools often have difficulty producing reliable quantities, and subsequently, particular attention should be paid to these special cases in quantity take-off.

Appendix 1: Product structures presented in the BIMs of different design disciplines
Source of product structure and information: x = primary (x) = secondary

Names of quantities/ building elements (Talo 2000 project nomenclature)	**Architectural BIM**	**Structural BIM**	**Building services BIM**	**Note**
1.1 Site elements				
1.1.1 Ground elements	(x)	(x)	(x)	
1.1.2 Soil stabilization and reinforcement elements		x		
1.1.3 Paved and green areas	x			
1.1.4 Site equipment	x			
1.1.5 Site constructions	x	(x)		
1.2 Building elements				
1.2.1 Foundations		x		
1.2.2 Ground floors	(x)	x		
1.2.3 Structural frame	(x)	x		
1.2.3.1 Civil defence shelters	(x)	x		
1.2.3.2 Bearing walls	(x)	x		
1.2.3.3 Columns	(x)	x		
1.2.3.4 Beams	(x)	x		
1.2.3.5 Intermediate floors	(x)	x		
1.2.3.6 Roofing decks	(x)	x		
1.2.3.7 Structural frame stairs	(x)	x		
1.2.3.8 Other stuructural elements		x		
1.2.4 Facades	x			
1.2.4.1 External walls	(x)	x		
1.2.4.2 Windows	x			
1.2.4.3 External doors	x			
1.2.4.4 Facade attachments	x			
1.2.4.5 Other facade sections	x			
1.2.6 Roofs	x			
1.2.6.1 Roof substructures	(x)	x		
1.2.6.2 Eaves structures	(x)	(x)		
1.2.6.3 Roofings	x			
1.2.6.4 Roof safety products	x			
1.2.6.5 Glass roof structures	x			
1.2.6.6 Skylights and hatches	x			
1.2.6.7 Special roof substructures	x			

1.3 Internal space elements				
1.3.0 Space objects	x			
1.3.1.1 Partitions	x			
1.3.1.2 Glass partitions	x			
1.3.1.3 Special partitions	x			
1.3.1.4 Balustrades and railings	x			
1.3.1.5 Internal doors	x			
1.3.1.6 Special doors	x			
1.3.1.7 Space stairs	x			
1.3.1.8 Other internal dividers	x			
1.3.2 Space surfaces	x			
1.3.2.1 Floor surface elements	x			
1.3.2.2 Floorings	(x)			
1.3.2.3 Veiling surface elements	x			
1.3.2.4 Ceiling finishings	(x)			
1.3.2.5 Wall surface elements	x			
1.3.2.6 Wall finishings	(x)			
1.3.2.7 Other space surfaces	(x)			
1.3.3 Internal fixtures	(x)			
1.3.3.1 and 2 Fittings	x			
1.3.4 Other internal space elements	x			
1.3.4.1 Maintenanace platforms and catwalks	x			
1.3.4.2 Fireplaces and flues	(x)	(x)	(x)	
1.3.4.3 Other special internal space elements	(x)			

Names of quantities/ **building services elements (HVAC2010 nomenclature)**	**Architectural BIMI**	**Structural BIM**	**Building services BIM**	**Note**
21 HVAC basic systems				The system is modeled in the scope stated in the design contract and modeling level of detail requirements.
21.1 Heating systems			x	
21.11 Central heating components			x	
21.2 Heat transfer components			x	
21.13 Heating terminal units			x	
21.14 Heating area parts			(x)	
2.1.2 Water and sewer systems			x	
21.21 Water and sewer system central components			x	

21.22 Water and sewer system transfer components			x	
21.23 Water and sewer system terminal units	(x)		x	
21.24 Water and sewer system area components		(x)	x	
21.3 Ventilation systems			x	
21.31 Ventilation central components			x	
21.32 Ventilation transfer components			x	
21.33 Ventilation terminal units	(x)		x	
21.34 Ventilation area components			x	
21.4 Cooling systems			x	
21.41 Central cooling components			x	
21.42 Cooling transfer components			x	
21.43 Cooling terminal units	(x)		x	
21.44 Cooling area components			x	
21.5 Fire prevention systems			x	
21.51 Fire prevention central components			x	
21.52 Fire prevention transfer components			x	
21.53 Fire prevention terminal units			(x)	
21.54 Fire prevention area components	(x)		x	
21.6 Civil defence shelter HVAC systems			x	
21.61 Civil defence shelter HVAC system central components			x	
21.62 Civil defence shelter HVAC system transfer components			x	
21.63 Civil defence shelter HVAC system terminal units	(x)	(x)	(x)	
21.64 Civil defence shelter HVAC system area components	(x)	(x)	(x)	
22 HVAC special systems				Scope determined by design contract and modeling level of detail requirements
22.1 Pneumatic systems			x	
22.2 Gas systems			x	
22.3 Steam systems			x	
22.4 Fluid systems			x	
22.5 Swimming pool water			x	

treatment systems				
22.6 Air technology systems			x	
22.7 Combustion engine HVAC systems			x	
Electric systems				
Transformers			x	
Appliances			x	
Main electric exchanges			x	
Conductor rails			x	
Compensation batteries			x	
Accumulator batteries			x	
Distribution centers			x	
Distribution frames			x	
Telecommunications system exchanges			x	
Security system exchanges			x	
Cable shelves and suspension rails			x	
Conductor grooves			x	
Floor ducts and casings			x	
Upright ascents			x	
Lighting fixtures			x	
Exit lights			x	
Backup and security lighting fixtures			x	
Loudspeakers			x	
Door control systems			x	
Building automation (“RAU”) centers			x	