Christoph Carl Eichler | Christian Schranz | Tina Krischmann | Harald Urban | Markus Gratzl | Alexander Gerger

BIMcert Handbook (Austrian Edition)

Basic Knowledge openBIM

Edition 2021

buildingSMART Austria

Christoph Carl Eichler | Christian Schranz | Tina Krischmann
Harald Urban | Markus Gratzl | Alexander Gerger

BIMcert Handbook (Austrian Edition)
Basic Knowledge openBIM

Christoph Carl Eichler | Christian Schranz | Tina Krischmann
Harald Urban | Markus Gratzl | Alexander Gerger

BIMcert Handbook (Austrian Edition)

Basic Knowledge openBIM

Edition 2021

buildingSMART Austria

ACKNOWLEDGEMENTS
The idea and the topics for this book were developed in the course of the research project *BIM-Zert-Standardised Qualification and Certification Model for Building Information Modelling in Austria.* This research project was funded by the Austrian Federal Ministry for Digital and Economic Affairs (BMDW) in the course of the FFG *Qualification Networks* track (*4th call for proposals*) in the FFG Research *Competences for Industry* programme.

IMPRESSUM
© 2021 Mironde-Verlag
© Text: Christoph Carl Eichler, Christian Schranz, Tina Krischmann, Harald Urban, Markus Gratzl, Alexander Gerger
© Grafics: Alexander Gerger
Layout: Birgit Eichler
Set: with the Lato font
Publisher: buildingSMART Austria . 1010 Wien, Eschenbachgasse 9

Made in Germany
www.mironde.com

ISBN **978-3-96063-044-9**
DOI 10.34726/1601

Christoph Carl Eichler
worked as an architect from 2006 to 2011. During this time, he realised numerous BIM projects in Austria, the Netherlands, and Germany. Since then, he has worked as a BIM consultant in numerous BIM pilot projects for public clients in the field of building construction and infrastructure, was involved in the ASI committee ASI 11/09 and ASI 15/11, and at European level in CEN/TC442. Since 2017, he has also been involved in more than 25 research projects on various aspects of digitalisation in collaboration with TU Wien and TU Graz. Since 2015, he has led several BIM training programmes at the Überbau Academy and Wifi Vienna. Since 2020, he has been a member of the buildingSMART Austria board and part of the examination board for the BIMcert training.

Christian Schranz
is Assistant Professor at TU Wien and heads the Centre for Digital Building Processes (TU Wien). He started his research at the University of Illinois at Urbana-Champaign, USA, and continued at TU Wien. His research focuses on the modelling of building structures (incl. life cycle assessment) and digitalisation in construction, in particular the use of openBIM and augmented reality. As a board member of buildingSMART Austria, he is responsible for quality management and openBIM training. He is part of the examination board for the BIMcert training.

Alexander Gerger
is a civil engineer and a research assistant at the Centre for Digital Building Processes (TU Wien). He works on timber construction, augmented reality, and openBIM and is co-author of various publications on these topics. In the EU-funded research project »BRISE-Vienna« he develops augmented reality use-cases for the openBIM building submission process.

Tina Krischmann
is an architect and works as BIM Operation Director at ODE office for digital engineering. She is one of the first Certified Trainers (BIM) of buildingSMART Austria, where she is also the deputy leader of the national working group »Digital Construction Submission«. In addition to numerous projects as BIM project manager, BIM project controller, and overall BIM coordinator, she is currently leading the working group for the implementation of the legal matter into the BIM method in the EU-funded research project »BRISE-Vienna« (digital building submissions).

Harald Urban
is deputy head of the Centre for Digital Building Processes (TU Wien), a state-certified master builder, and one of the first Certified Trainers (BIM) of buildingSMART Austria. He heads the national working group »Digital Building Submission«, which he is developing further as openBIM building submission in the EU-funded research project »BRISE-Vienna«. He supervises numerous research projects on the topic of digitalisation in the construction industry and is co-author of the study »Potentials of digitalisation in the construction industry« commissioned by the WKO and BMVIT.

Markus Gratzl
is a building physicist working at the interface between practice and science: In his engineering office Gratzl he dedicates himself to the entire range of simulations under the name Green.Building.Simulation – from building and plant simulations to flow and daylight simulations. As a professor for simulation methods in building physics at the Smart Building degree programme of the Salzburg University of Applied Sciences, he mainly leads cooperative R&D projects. Among other things, he developed and managed the FFG qualification network »BIM-Zert«.

CONTENT

Prologue to the first edition 2021

Building Information Modelling (BIM) is the next big step for everyone involved in the construction process. The BIM method will play a central role in the entire process over the life cycle of a building. Current BIM education still lags a little behind this development. It often focuses mainly on the application of BIM-enabled software. Functional BIM training is usually neglected. Especially in a BIM project, the responsibilities of the individual participants and the correct communication between these participants are extremely important. All participants must know these roles and tasks.
In the course of the BIM-Zert research project, researchers from four different leading universities (FH Salzburg-Kuchl, TU Wien, Graz University of Technology, FH Kärnten Spittal/Drau) developed a standardised qualification and certification model for BIM in Austria together with practitioners experienced in openBIM, the Überbau Akademie and buildingSMART Austria. The recommendations from this research project are now being continued by buildingSMART Austria under the name BIMcert and correspond to the levels of the »Professional Certification« programme of buildingSMART International.
The idea for this book came from the meetings during the project and from the feedback of the participants in the first run. This book is dedicated to the functional openBIM training and describes all topics for the certification levels of the BIMcert training. We would like to thank all the colleagues who worked on the project for their support during the project and the many ideas that also went into this book. Special thanks go to buildingSMART Austria, in particular Alfred Waschl, for their/his support in producing this essential basis for future BIM education.

Christoph Carl Eichler, Christian Schranz, Tina Krischmann,
Harald Urban, Markus Gratzl, Alexander Gerger

Vienna, September 2021

1 Introduction

Building information modeling (BIM) represents the »next big step« for all those involved in the planning process in the construction industry. It is foreseeable that in a few years – as happened with the introduction of CAD in the 1990s – the entire handling process over the life cycle will adapt, with the BIM method taking on a central role. This will require appropriate BIM training in the future. The verification of BIM knowledge must be regulated in internationally comparable quality standards for personal knowledge and competencies. Therefore, buildingSMART International has developed a professional certification. This book deals with the topics of this professional certification.

1.1 Who is buildingSMART?

buildingSMART International (bSI) is an international nonprofit organization which is organized as an association. It was founded in the 1990s as the Industry Alliance for Interoperability (IAI), shortly thereafter renamed International Alliance for Interoperability, and became buildingSMART in 2005. More than 20 national organizations (local chapters) on four continents have since been formed, including buildingSMART Austria (bSAT), buildingSMART Germany (bSDE), and buildingSMART Switzerland (bSCH).

The core objective of buildingSMART (bS) is to improve the exchange of data and information between different software programs in the construction industry. This is intended to optimize collaboration and the digital workflow. For this reason, buildingSMART has also been able to sign up all relevant software manufacturers as members. buildingSMART supports the importance of open (i.e., software-neutral) and interoperable solutions and stands for international, interoperable, open (data exchange) standards for BIM. These standards facilitate the creation of a comprehensive digital environment for the entire project and asset life cycle, providing significant benefits. buildingSMART aims to achieve their core objective through three core programs: Standards, Software Certification, and Membership Program.

As an independent association, buildingSMART develops its own standards for data exchange and collaboration. The best-known standards are the IFC and BCF, with the IFC having been published as an ISO standard in 2013 (ISO 16739). In addition, bSI also develops bSDDs for the description of objects and their attributes, MVDs for the definition of subsets of an IFC data model, and IDMs for the description of information requirements. With these standardisations, bSI significantly supports the use of openBIM (BIM with open standards).

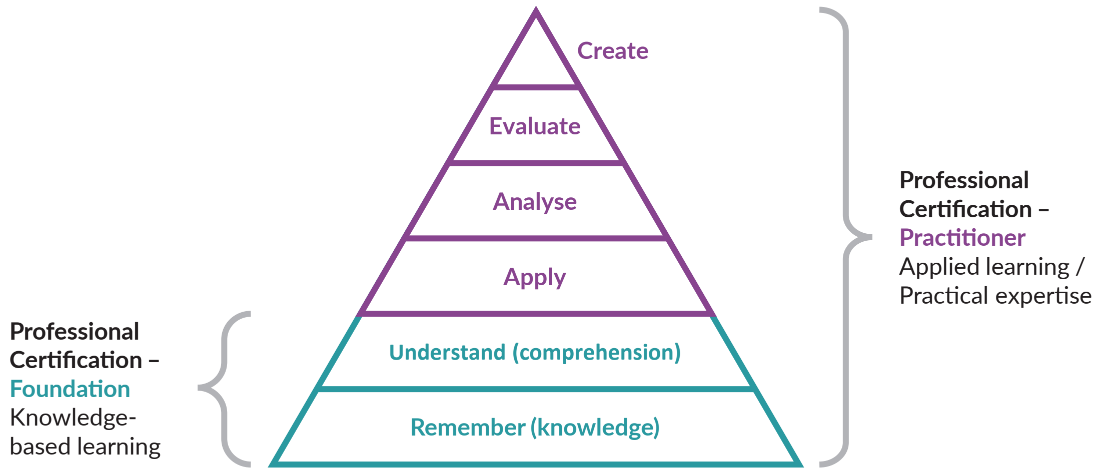
Software manufacturers can have their BIM-capable products certified by buildingSMART for the correct implementation of IFC. This certification guarantees a consistently high transmission quality.

The buildingSMART Member Program promotes the understanding and use of openBIM standards and solutions. This includes the buildingSMART »Professional Certification« program.

1.2 buildingSMART professional certification

BIM users can have their BIM knowledge certified via buildingSMART. For this purpose, buildingSMART has introduced the professional certification. The buildingSMART professional certification consists of two levels:

- Professional Certification – Foundation
- Professional Certification – Practitioner

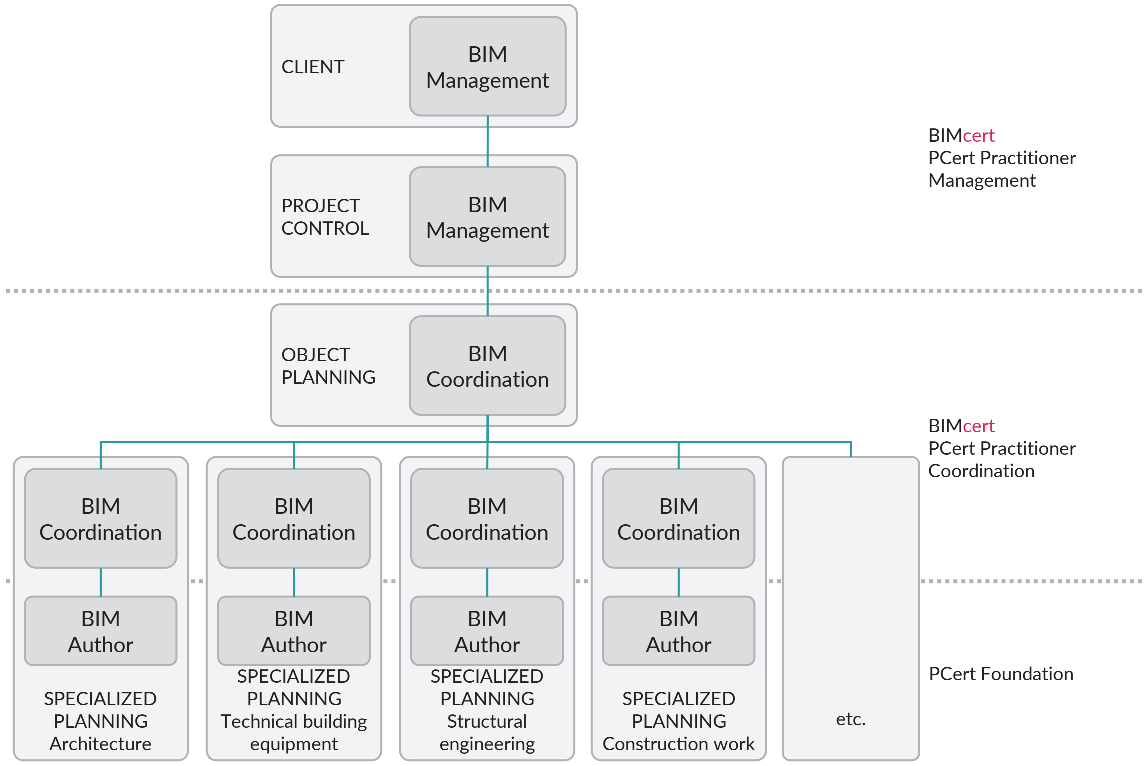


The bSI »Professional Certification – Foundation« tests basic knowledge and the understanding of openBIM use in BIM projects. This certification is internationally defined by bSI and awarded on the basis of a multiple-choice test.

The bSI »Professional Certification – Practitioner« tests the knowledge of the practical use of openBIM over the entire BIM project from project initiation to handover of the building to the client. This certification level is not yet defined internationally.

1.3 BIMcert – bSAT professional certification

In the research project BIM-Zert, leading Austrian universities together with buildingSMART Austria developed a standardized qualification and certification model for BIM in Austria, which also includes certification level »bSAT Professional Certification – Practitioner«. This certification contains two parts: BIM coordination and BIM management.



The training for the professional certification takes place in lecture blocks focused on specific topics, which are shown in the following table. The practitioner certifications are not based on each other; rather they address the target groups BIM coordination and BIM management separately. The first two lecture blocks are identical for both target groups. The following table shows which chapters of this book correspond to the certification-related lecture blocks of the professional certification (BIM foundation, BIM coordination, BIM management).

In addition to this book, the »Professional Certification – Practitioner« test conducted by bSAT is based on the rules and regulations (EIR, BEP) and service specifications (LM BIM) published by bSAT/bSCH.

Modules and content (the corresponding levels are listed in brackets)	*Chapter/Section*
Module 1: Basics (BIM foundation) (2 days)	
Basics – general and digitalisation	2
Basic terms (IFC, bSDD, BCF, DataTemplates)	2
Basics – BIM applications	2
Basics – openBIM project and standardisation	1, 2
Certification exam »Professional Certification – Foundation«	–

Module 2: Advanced basics (BIM coordination, BIM management) (2 days)	
Building operation	future releases of the book
Digital (openBIM) construction management	4.5.3
Model-based communication	3.1, 3.2, 3.3, 3.4, 3.5
Standardisation (national, European, international)	2.5, 2.6
Module 3: General setup phase (BIM coordination, BIM management) (3 days)	
Data structure tools and data feature server	4.3
Communication and cooperation	4.2, 4.3
Practical example of the construction phase	workshop*
Module 4: Coordination (BIM coordination) (4 days)	
BIM-supported tendering, awarding, and invoicing (AVA)	workshop*
BIM coordination	workshop*
Module 5: Functional training (BIM management) (2 days)	
BIM service specifications, regulations, and contracts	4.2.2, bSAT-BEP, bSAT-EIR, bSAT-LM BIM
BIM project implementation and organization	4, bSAT-BEP, bSAT-EIR, bSAT-LM BIM
Quality management	4.3
Module 6: Process training (BIM management) (2 days)	
Process management	literature
Risk management	literature
Process modeling	future releases of the book
Handover to building operation	future releases of the book
Module 7: Practical workshop (BIM coordination, BIM management) (2 days)	
Collaboration colloquium	5, workshop*

** In the respective BIMcert course, the certified trainers use practical examples from their own experience that cover these topics. These topics are therefore not included in this book.*

Certification procedure
The bSI »Professional Certification – Foundation« is the first level. After attending the two-day foundation course, the examination containing 25 questions can be taken. In addition, there is a question block of five multiple-choice questions on national openBIM topics which is expected to be available soon for Austria. The corresponding topics are covered in this book. Certification is awarded to those who answer at least 75% of the questions correctly.

Only after obtaining the foundation certification can the practitioner courses be attended (bSAT »Professional Certification – Practitioner«). After attending the courses, the certification examination takes place as a board examination in front of an examination board of buildingSMART Austria. Prior to this, a written paper on a topic of BIM coordination or BIM management must be submitted to buildingSMART Austria. The oral board examination covers both the submitted paper and the theoretical material of the courses (Chapters 2, 3, and 4 of this book).

Practitioner certification can be pursued independently of each other (i.e., BIM coordination first or BIM management first). If both are pursued simultaneously, two written papers must be prepared and submitted to buildingSMART Austria.

1.4 Structure and conventions
This book contains the topics for the buildingSMART »Professional Certification«. Chapters 1 and 2 deal with the basic knowledge of digitalisation, the tools and structures required for BIM, the organization including rules and regulations as well as standardisation. This knowledge is essential for the »Professional Certification – Foundation« certification.

Chapter 3 deepens the knowledge from Chapter 2 and explains important openBIM terms in detail. This chapter starts with a detailed explanation and description of the IFC data structure and then deals with the MVD, IDM, and BCF developed by buildingSMART. Finally, it discusses the CDEs, levels of detail, and the interrelationships of standardisation.

Chapter 4 is entirely dedicated to the use of openBIM. The use of openBIM is explained step by step for the individual project phases of the life cycle of a building, from the project idea to planning and construction. The next editions of this manual will also include the final project phases.

These four chapters cover all topics required for the »Professional Certification – Practitioner« for Austria.

2 Basic knowledge
This chapter provides the basics for all those who want to take the buildingSMART »Professional Certification – Foundation« exam. It provides an easy introduction to openBIM. All basic terms of openBIM are explained here. Anyone involved in an openBIM project can thus rely on a common language with the same terms.

- Relevant for BIM novices, BIM practitioners, and BIM experts who want to use the same terms, and all those who want to take the foundation exam.
- No prior knowledge is required.

Important abbreviations appearing in this chapter are
(Note: some abbreviations are from the German term)

AG	Client
AIM	Asset information model
AIR	Asset information requirements
AN	Contractor
AR	Architecture
ASI	Austrian Standards International
AVA	Tendering, awarding, billing
BCF	BIM collaboration format
BE	BIM-Ersteller (BIM designer)
BEP	BIM execution plan
BFK	BIM-Fachkoordination (BIM specialist/technical coordination)
BGK	BIM-Gesamtkoordination (overall BIM coordination)
BIM-ÖBA	BIM local construction supervision
BPL	BIM-Projektleitung (BIM project management)
BPMN	Business process modeling and notation
BPS	BIM-Projektsteuerung (BIM project management)
bSAT	buildingSMART Austria
bSCH	buildingSMART Switzerland
bSDD	buildingSMART data dictionary
bSDE	buildingSMART Germany
bSI	buildingSMART International
CDE	Common data environment
CEN	Comité Européen de Normalisation
CV	Coordination view
DIN	German Institute for Standardisation

DTV	Design transfer view
DWG	Drawing (file extension)
DXF	Drawing interchange file format
EIR	Exchange information requirements
FIM	Facility information model / Facility information management
GUID	Globally unique identifier
HOA	Fee regulations for architects
IDM	Information delivery manual
IFC	Industry foundation classes
IFD	International Framework for Dictionaries
ISO	International Organization for Standardisation
LM BIM	Performance models BIM
LM.VM	Performance models. Compensation models
LOG	Level of geometry
LOI	Level of information
LOIN	Level of information need
MEP	Mechanical, electrical, and plumbing (building services)
MVD	Model view definition
ÖBA	Local construction supervision
OHB	Organization manual
OIR	Organizational information requirements
PDF	Portable document format
PF4.0	Plattform 4.0
PIA	Project information requirements (PIR)
PIM	Project information model
Pset	Property set
RV	Reference view
SIA	Swiss Association of Engineers and Architects
STEP	Standard for the Exchange of Product Model Data
TGA	Technical building equipment
TWP	Structural engineering

2.1 Digitalisation basics

For a long time, the construction industry was one of the sectors least affected by digitalisation. In many areas and for a long time there was a high degree of process inefficiency, as project-oriented instead of process-oriented thinking prevailed. As a result, communication, risk management, and contract implementation were in need of improvement. There is particularly high potential for optimisation in terms of wasted resources. In addition, the construction industry is very small-scale, specialized, and fragmented. Smaller companies in particular have difficulties in adapting to digital innovations. For a long time, this slowed down the digitalisation of the construction industry.

Digitalisation is opening up new optimisation potential for the construction industry. This is why this so-called fourth industrial revolution is now also gaining momentum in the construction industry. The advantages of digitalisation are gradually being recognized in the construction industry and should help to eliminate some existing problems. The advantages of digitalisation and digital models include the following:

- cost reduction,
- networking,
- information transparency,
- technical assistance,
- increased efficiency,
- improved communication and collaboration,
- flexibility,
- time savings,
- establishment of new business models,
- environmental friendliness (less waste of resources),
- increase in productivity,
- competitive advantages and
- greater attractiveness of employers for new employees.

Good decision-making requires good data

BIM is considered a strong driver of digitalisation. BIM promotes successful communication and collaboration between the parties involved in a construction project. This decisively supports quality assurance. The core of BIM is the digital building model, which contains the information in the form of geometries and alphanumericals. Thus, BIM provides an optimized method for creating, exchanging, and maintaining digital building data.

The possibility of BIM-based visualisation of structures and their data can accelerate decision-making processes. The digital exchange of project information reduces fragmented work processes and supports the provision of information at the appropriate time, which can limit the amount of unstructured information and which improves the flow of information between stakeholders.

This offers a major advantage for construction professionals. The digital model bundles all the information provided by individual stakeholders. The users of the digital models create, maintain, and use the geometries and information of the model. The collaboration takes place in a common data environment (CDE), independent of location. The potential of CDEs is the efficient communication, documentation, and alignment of information (data) from different sources. Since all components have attributes and these are stored in the system, quantities and costs can be planned and determined earlier and more precisely. The »accuracy« of a digital model is determined by the level of detail, e.g., the level of geometry (LOG) for geometric requirements and the level of information (LOI) for alphanumeric requirements.

One basic principle of BIM is consistent data and information exchange. Digital models support ensuring data consistency in the building database. Modeling guidelines exist for this purpose. The optimized information management improves collaboration/cooperation as well as communication and thus helps to reduce or even avoid delays in the project process.

BIM benefits for clients and operators
The use of BIM delivers many benefits not only to designers but especially to clients and operators of structures. The digital models support the transfer of consistent and digital project information of the structure to building operation and maintenance, and they help to handle common asset management tasks. By regularly archiving the model, a long-term archive of the project (including its planning) is built. This provides the opportunity to compare different stages in the planning process and to evaluate errors. Through the examination of previous projects, requirements from operations can be fed back efficiently into the planning of current projects. This provides a significant increase in evaluation capabilities, risk reduction, and cost reduction in building and maintaining facility management (FM) systems. Information for operations can be transferred to the model at a very early stage. The target/actual comparison is easier. Operational requirements can be visualized before completion and defined during the planning phase. This can help to better predict and to reduce operating expenses. Shared consistent information models reduce the time and cost of creating coordinated information. The models contain all relevant property information, which permits the centralized digital data management of all important building information.

It is important to perform and maintain data management conscientiously. Unstructured storage of collected project data leads to poor data management and increases the processing effort. Therefore, data must be stored and made available to all project partners in a systematic manner. Conscientious data management is therefore very important for effective communication and coordination. Digital building models created with BIM offer the possibility to represent and describe all information with the help of objects and components. This integrates all aspects of the value chain throughout the life cycle, avoids misunderstandings and improves the basis for decision-making.

BIM introduction in a company
The implementation of BIM in a company offers many advantages. Digital information models can contain almost all data sets required for the successful completion and operation of structures. Conclusions and comparisons can be drawn at every stage. The sensible digitalisation of internal processes/workflows leads to increased efficiency and thus cost savings (personnel costs, construction costs, operating costs). Sensible digitalisation requires the analysis of existing processes and possibly an adaptation of these processes to the possibilities of digital tools.

Automation can save effort. Systematic, software-supported error-checking means that conflicts are less likely to be overlooked. Visualisations lead to a better and faster understanding of conflicts. Conflicts can be resolved faster by the specialist planners. Furthermore, a high level of BIM competence improves the reputation of a company or institution.

The introduction of BIM is a holistic corporate decision which requires a BIM strategy. This strategy includes fundamental considerations about the desired added value through the introduction of digital methods, the planned applications, training concepts, and process definitions. The strategy resembles a set of specifications. The desired added values can be cost truth and transparency, adherence to schedules, high project quality within the set time and cost framework, the streamlining of internal processes, increased efficiency, cost savings, or improved communication.

The BIM strategy must be aligned with the company's goals so that the investments are used wisely. The measures take into account the current performance of the company as well as its goals and other strategies. A gap analysis between the target and actual situation is carried out to find existing gaps. Only when the required investments in personnel, processes, framework conditions, data, and technologies are aligned with the goals should the implementation of BIM be started. Implementation is a strategic process, during which existing concepts and processes may have to give way to new ones.

The introduction of BIM also includes challenges. There is often a temporary reduction in productivity at the beginning, which depends on the entry requirements and goals. The acquisition and training of competent employees must take place at the beginning of the implementation, which results in increased initial investment for training, hardware, and BIM-capable software. Furthermore, the requirements for the technical infrastructure need to be determined. These investments are likely to pay for themselves within a short time frame. Established contract and remuneration models must be redefined. Billing rules also need to be adapted to the BIM software.

It is important for an organization to know its own BIM maturity level in order to know its performance compared to the competition. At the lowest BIM maturity level, BIM implementation is characterized by the absence of a strategy and the non-systematic application of BIM-enabled software solutions. At the highest BIM maturity level, the implementation strategy and organizational models are continuously reviewed and realigned; the software solutions are used in a solution-oriented manner and changes in processes are introduced proactively.

To assess its BIM maturity level, a company must look at its internal process management (workflows) and realistically assess the existing competence of its personnel. This yields the status quo and provides the basis for defining the BIM goals and establishing an action plan.

The implementation of BIM in a company goes hand in hand with increased digitalisation. Therefore, data security is becoming increasingly important. Effective measures to ensure data security include data encryption and the establishment of an effective access rights structure on the server environments or cloud-based platforms. These hierarchies must be reviewed constantly during their lifetime to prevent unauthorized access or loss and corruption of information.

Digitalisation further raises legal issues. Questions regarding liability and the copyright for the digital model content, as well as the rights for data use, arise.

Steps toward digitalisation

- Taking stock, examining the current situation, identifying opportunities
- Strategic concept and development of an action plan
- Tool selection
- Employee training
- Ongoing optimisation

2.2 Tools

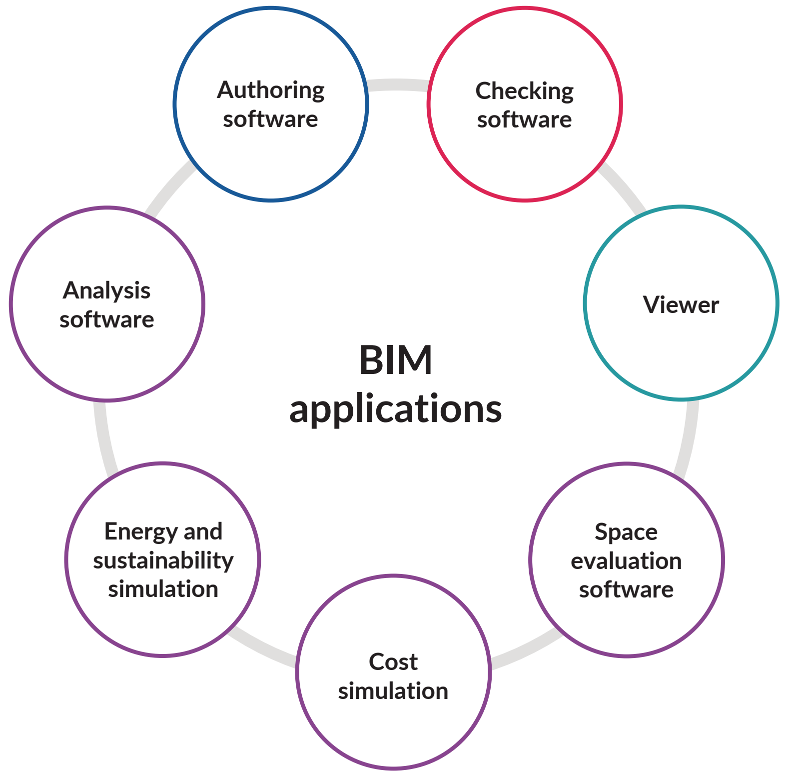
In this section, BIM software applications, collaboration platforms (common data environments – CDEs), and data structure tools are presented.

2.2.1 BIM software applications

In BIM, a variety of software products are used, which are referred to as BIM tools. The term »BIM software applications« refers to tools that are used to create, check, and evaluate model data. A BIM software application must meet the requirements and functionalities of the BIM method. Whether a software application already in use meets these conditions is shown by its status in the certification issued by buildingSMART (see QR code).

In projects, preference should be given to certified BIM software applications (status = finished). If noncertified BIM software applications are used, the requirements must be checked to ensure that the application is suitable. These requirements are defined in the regulations (EIR and BEP).

The following graphic provides an overview of the different types of BIM software applications:



The main BIM software application is authoring software, which is used to create the model content according to the relevant planning, discipline, and BIM organizational unit.

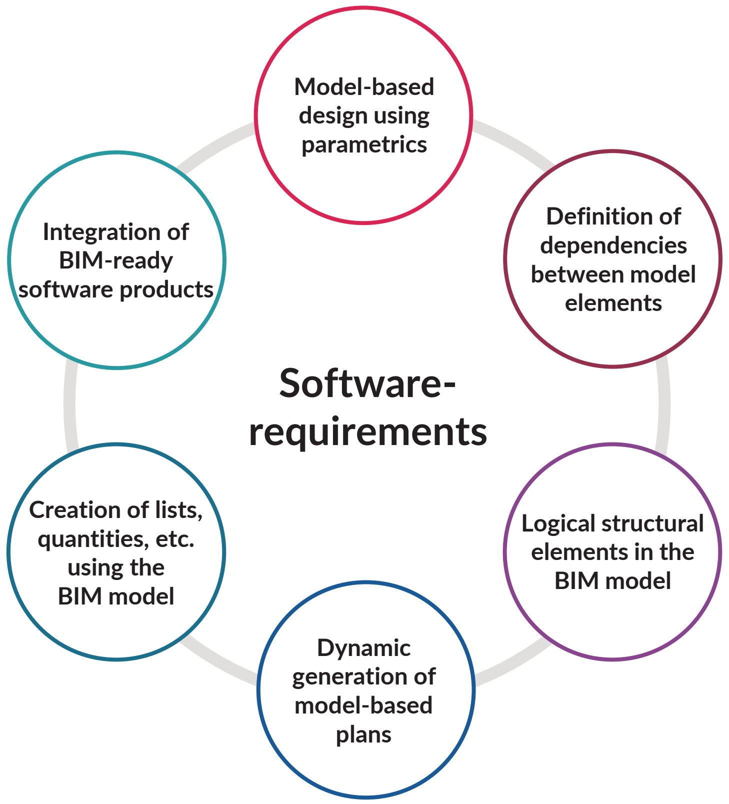
Checking software is a software application that checks but does not change model content. It is the most important application for quality management.

A viewer is software that only displays the content of models; it can neither check nor reuse model information.

The other software applications take model information (released and checked by checking software) and draw on this content for their own uses, calculations, and evaluations.

The choice of software application should always be well considered. Besides suitability for use in BIM (information found in the certification), the intended use, as well as acquisition and maintenance costs, should be taken into account. The following questions must be considered: Does the software manufacturer provide good support? Is good training available close to the site?

The most important requirements for software applications (especially with regard to interoperability) are summarized in the following figure:



A BIM software application must therefore

- be able to map, derive, and communicate model content according to the IFC data structure/interface (geometric and alphanumeric),
- be able to establish the dependencies of model elements on each other (e.g., what floor a wall belongs to or windows in a wall),
- be able to map and read logical structural elements (e.g., MEP systems),
- dynamically derive plans (mainly in PDF and DWG/DXF formats),
- be able to create evaluation lists of model content, and
- have the functionality to integrate with all other BIM-enabled software applications and BIM tools that are not from the same software group.

2.2.2 Collaboration platforms

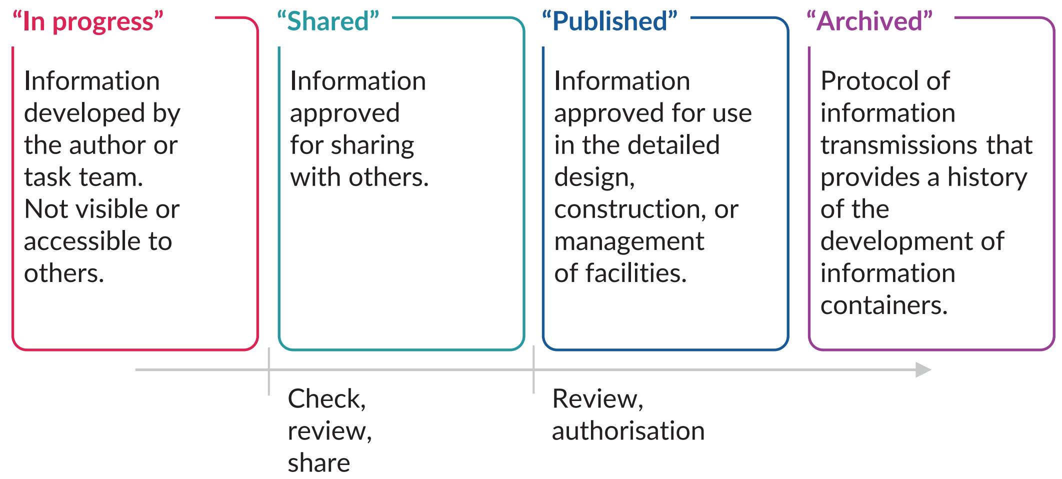
Collaboration platforms are BIM tools that offer web-based services for handling collaboration in projects. They are used to centrally handle project-related communication and data exchange. They offer a common data environment (CDE). Their major advantage lies in the uniform structuring of project handling (if required, also across projects).

CDEs are thus used for the information management of projects and properties. CDEs can be considered central project rooms for storing and exchanging all project information with all project participants, so all project knowledge is assembled in them and is quickly available. They provide controlled (person-dependent) access to project information, clearly defined exchange processes, and unambiguously defined document and model status. They thus ensure communication transparency and improve the exchange of information. All collaborative activities required for the creation of the PIM and AIM take place in the CDE.

ISO 19650 describes the concept of a common data environment (CDE). According to ISO 19650, a CDE should support three different information container states:

- WORK IN PROGRESS
- SHARED
- PUBLISHED

In addition, there should be an archive container that records all the operations of the other information containers in the form of a log. This allows the development of a combined and collaborative information model.



Furthermore, comprehensive data security must be provided and information exchanges must be verified by control authorities. During information transfer, the data must be versioned and logged.

Examples of typical collaboration platforms currently used in projects for higher-level collaboration are Aconex from Oracle, and Conclude CDE and tpCDE from Thinkproject. For collaboration within a specialist discipline, integrated collaboration platforms are sometimes used, such as Autodesk BIM 360 or Graphisoft BIMcloud.

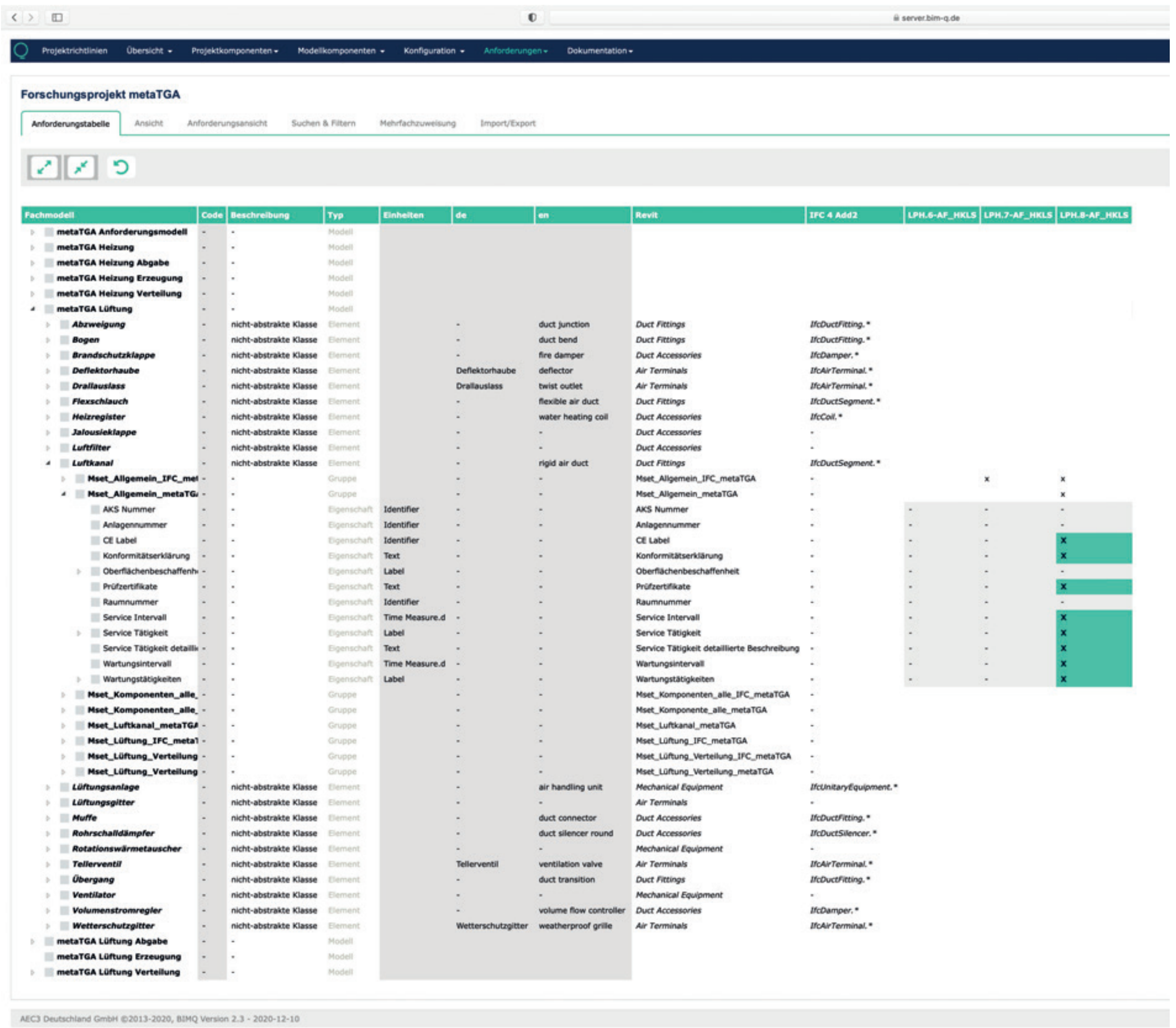
2.2.3 Data structure tool

Data structure tools are another type of BIM tool. They are web-based services for the creation and modification of individual data structures and of the levels of detail based on them. They offer central moderation and integrated distribution to various channels (BIM software applications, BIM rulebooks, etc.), thereby minimizing the respective individual adaptation effort.

Data structure tools support the definition of the EIR and the creation of project-specific BIM guides. They allow the direct derivation of the checking rules for the BIM checking software. This improves the quality management and quality control of the BIM models.

A typical example of a current data structure tool is BIM-Q from AEC3 GmbH. This web application allows

- the creation of individual data structures and the assignment of content to different project phases or use cases,
- the structuring of associated mappings of external data structures (e.g., **IFC2x3, IFC4, IFC4.1**),
- the creation of corresponding mappings of program-specific data structures (e.g., Allplan, ARCHICAD, ProVi, Revit, Vectorworks) and the output of the respective configuration files,



- the export/reimport of all database content into XLS files for further processing in table editing programs,
- the automatic creation of documents describing the data structure specifications (LOI annex of EIR), and
- the automatic creation of bases for model-checking routines in BIM checking software.

2.3 Structure/data schema

This section provides an introduction to the IFC data structure, the bSDD platform, BCF comments, and DataTemplates.

2.3.1 IFC data structure

IFC stands for industry foundation classes. It is an open data format for building information based on the STEP standard (STEP = Standard for the Exchange of Product Model Data). Since 1995, buildingSMART International has been developing IFC as part of the openBIM standard. Since 2013, IFC have been regulated in ISO 16739. buildingSMART also recommends using IFC for referencing and archiving models.

With the current version IFC4, all essential trades of building construction can be mapped in the data structure. For the upcoming version IFC5, it is planned to integrate the infrastructure areas road, rail, bridge, and tunnel and the associated routing (IfcAlignment).

IFC ensures the vendor-neutral transfer of building information. Therefore, all known national BIM standards refer to IFC.

IFC are integrated in all common BIM software applications. Software certification by buildingSMART International ensures consistently high transmission quality. The software manufacturers must complete the associated certification process for each IFC version.

The IFC specification uses three structures: location structure, functional structure, and material structure.

The location structure defines the spatial structure of a building in IFC. It declares building sites, structures located on them, floors located in them, as well as the rooms present on a floor.

Buildings are mapped within the functional structure by breaking them down into individual functional element classes: e.g., walls, ceilings, columns, doors, or windows. Each element (element instance) is given a unique identifier (GUID). The BIM software application generates this unique declaration.

buildingSMART International — Home | Standards | Services | Resources

IFC Specifications Database

Official releases of the IFC specification are listed here, as well as their components including HTML, EXPRESS, XSD/XML, and OWL documentation and formats.

Release Notes and Errata for all versions can be found here.

Search:

Version	Name (HTML Documentation)	ISO publication	Published (yyyy-mm)	Current Status	HTML download (ZIP)	EXPRESS	XSD	pSet XSD	OWL HTML	RDF	TTL
4.3.rc.2	IFC4.3 RC2	-	2020-11	Candidate	ZIP	EXP	IFC4.3 RC2.xsd	-			
4.3.rc.1	IFC4.3 RC1	-	2020-04	Archived	ZIP	EXP	IFC4x3_RC1.xsd	-			TTL IFC4.3 RC1
4.2.0.0	IFC4.2	-	2019-04	Withdrawn	ZIP	EXP	IFC4x2.xsd	-			
4.1.0.0	IFC4.1	-	2018-06	Official	ZIP	EXP	IFC4x1.xsd	-	ifcOWL IFC4.1	RDF	TTL
4.0.2.1	IFC4 ADD2 TC1	ISO 16739-1:2018	2017-10	Official	ZIP	EXP	IFC4.xsd	-	ifcOWL IFC4 ADD2 TC1	RDF	TTL
4.0.2.0	IFC4 ADD2	-	2016-07	Retired	ZIP	EXP	IFC4_ADD2.xsd	-	ifcOWL IFC4 ADD2	RDF	TTL
4.0.1.0	IFC4 ADD1	-	2015-06	Retired	ZIP	EXP	IFC4_ADD1.xsd	-	ifcOWL IFC4 ADD1	RDF	TTL
4.0.0.0	IFC4	ISO 16739:2013	2013-02	Retired	ZIP	EXP	ifcXML4.xsd	PSD_IFC4.xsd	ifcOWL IFC4	RDF	TTL
2.3.0.1	IFC2x3 TC1	ISO/PAS 16739:2005	2007-07	Official	ZIP	EXP	IFC2X3.xsd	PSD_R2x3.xsl	ifcOWL IFC2x3 TC1	RDF	TTL
2.3.0.0	IFC2x3	-	2005-12	Retired	ZIP	EXP	-	-	ifcOWL IFC2x3	RDF	TTL
2.2.1.0	IFC2x2 ADD1	-	2004-07	Retired	ZIP	EXP	-	-	-	-	-
2.2.0.0	IFC2x2	-	2003-05	Retired	ZIP	EXP	-	-	-	-	-
2.1.1.0	IFC2x ADD1	-	2001-10	Retired	ZIP	EXP	-	-	-	-	-
2.1.0.0	IFC2x	-	2000-10	Retired	ZIP	EXP	-	-	-	-	-
2.0.0.0	IFC2.0	-	1999-10	Retired	-	-	-	-	-	-	-
1.1.1.0	IFC1.5 ADD1	-	1998-08	Retired	-	-	-	-	-	-	-
1.1.0.0	IFC1.5	-	1998-01	Retired	-	-	-	-	-	-	-
1.0.0.0	IFC1.0	-	1996-12	Retired	-	-	-	-	-	-	-

The table IFC Release Database was last modified at 2020-11-11 13:07:45 by Technical Coordinator.

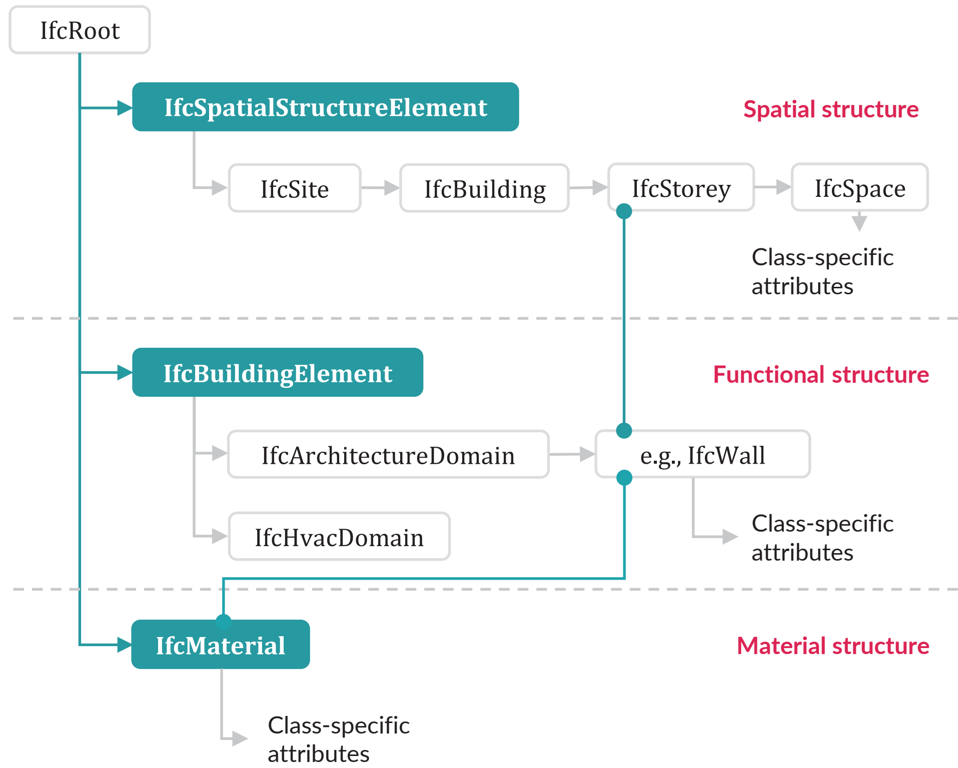
Chapter 2 – Basic knowledge

2.3 Structure/data schema

Each functional element class is optimized for the mapping of its functional domain. Therefore, it carries a standardized basic set of characteristics for describing relevant properties (parameters) as well as its typical geometry (attributes). The characteristics are organized into groups (so-called Psets = property sets). Each element class carries a typical Pset which carries the most essential characteristics. This Pset is designated with the suffix »Common«, e.g., Pset_WallCommon or Pset_DoorCommon. Psets can also apply to several element classes at once, e.g., Pset_Warranty.

How is IFC organized?

The data structure



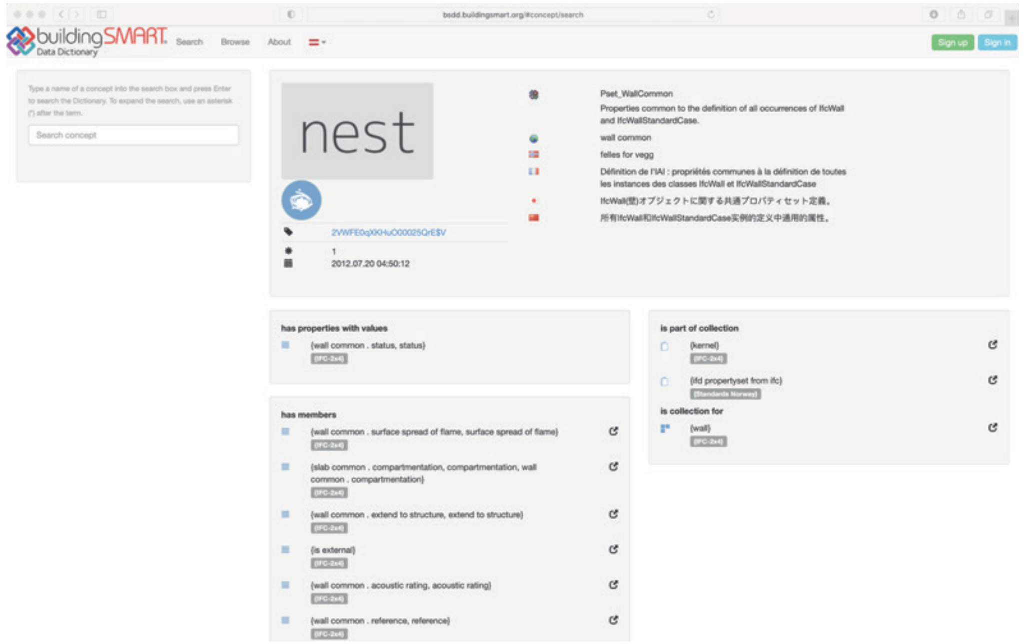
All functional elements are linked to floors and are thus also associated with a building. In addition to alphanumeric (attributes, parameters, and characteristics) and geometric information, an IFC file also contains object relationships.

Besides the location structure and the functional structure there is also a material structure in the IFC data structure used for declaring material-related properties. Unfortunately, this is implemented very heterogeneously in the BIM software applications currently available on the market. This should change in the medium term with the introduction of ISO 23386. This standard on data templates regulates the interaction of building information with material and product information. Therefore, a change in the material data structure is to be expected with the release of IFC5 – and after the release of IFC5 this change is to be implemented in BIM software applications.

2.3.2 bSDD-platform

bSDD stands for buildingSMART Data Dictionary. It is a web-based service for the creation and consolidation of individual data structure supplements (ontologies) based on ISO 12006-3. The associated possibility of providing multilingualism is seen as an advantage. bSDD is not a standard; it is owned by buildingSMART. It is based on the open IFD (International Framework for Dictionaries) standard.

The bSDD platform serves as a library of objects and their attributes. Each information stored on the bSDD platform is given a (language-independent) identifier/designation and is incorporated into a classification system. To do so, the bSDD platform assigns a unique identifier (bSDD GUID). Objects and their attributes (parameters, characteristics) can thus be identified unambiguously.



As content, the bSDD platform is able to carry individual element classes, individual Psets, individual features, or individual values of a feature. The entity that creates (declares) the content is responsible for each stored content. Other entities can add their own translations to such a declaration.

2.3.3 BCF-comments

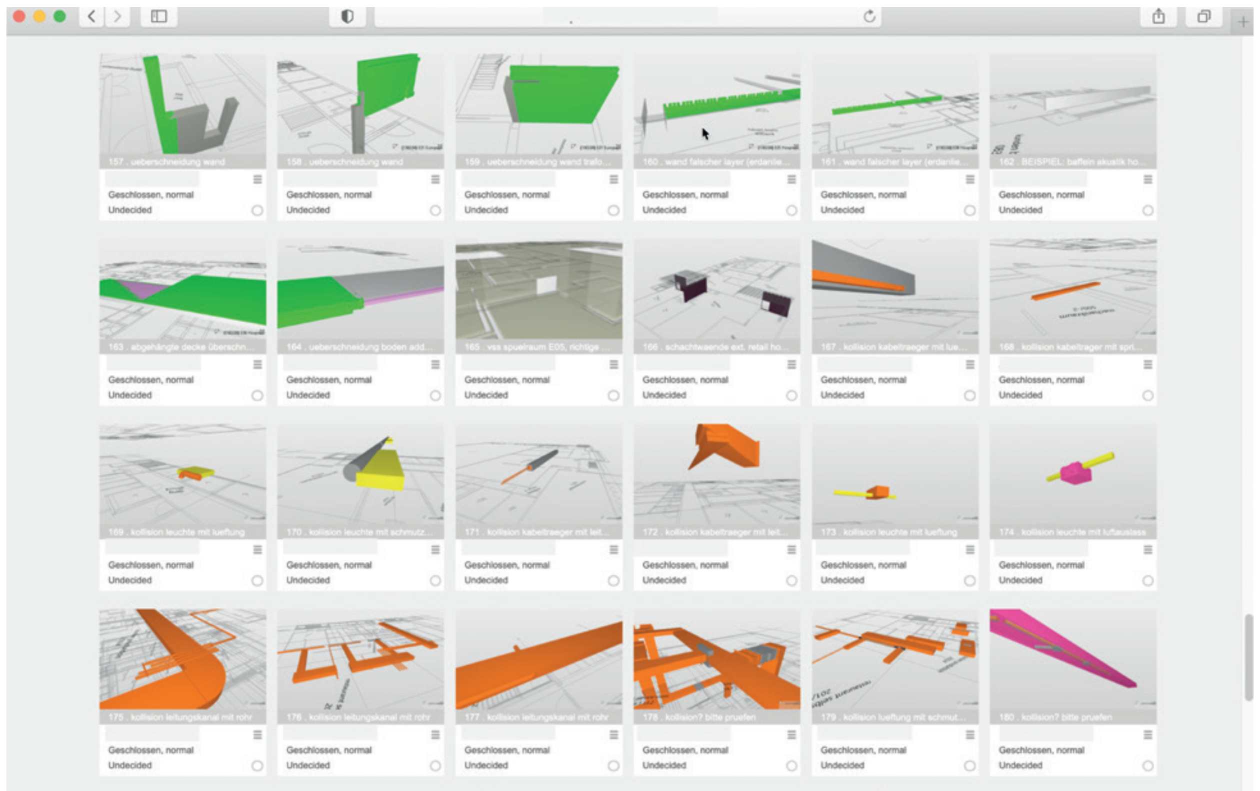
BCF stands for BIM Collaboration Format and is an open data format for model-based communication. Introduced in 2009 by Solibri Inc. and Tekla Corporation, it was subsequently adopted by buildingSMART International as part of the openBIM standard.

BCF is used during the work process to simplify the exchange of information (based on the IFC exchange format) between different software products. The current version BCF 2.1 allows the transfer of

- model-related comments (so-called issues),
- the affected elements in the model (via the object GUIDs), and
- reproducible screen clippings

between different BIM applications. This model-based communication improves coordination. Thus, information about problems in the model, their location, viewing direction, component, remarks, user, time, or even changes in the IFC data model can be exchanged in a targeted manner. The goal is to transfer the relevant information and not the entire model. The scope of the functions for the transfer of properties between different models will be expanded in the next versions of BCF.

BCF is integrated in all common BIM applications. In some cases, special additional modules (AddOns) are required to extend the range of functions.



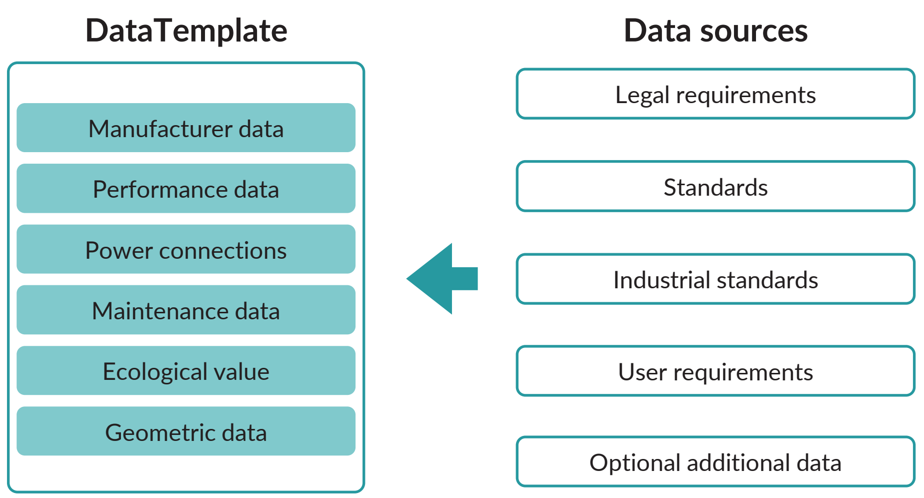
2.3.4 DataTemplates

DataTemplates is a symbolic term for digital construction products. This is a container-based technology for digitally mapping the interaction of harmonized product standards which has been regulated since 2020 by ISO 23386.

The organization of the DataTemplates into different building product structures, along with their content, is based on the specifications given in the harmonized product standards. This conformity is essential, since all approval processes in the industry are based on these specifications, and only in this way can the completeness of the information in the DataTemplates for productive use be guaranteed. Furthermore, it is planned to integrate the sustainability data (see EPD – environmental product declaration) of a building product according to ISO 22057 in the DataTemplates.

A distinction is made between generic (product-neutral) DataTemplates and specific (product-related) DataTemplates. This makes it possible to apply processes that are compliant with procurement law. In the planning phase, generic DataTemplates can be used to precisely describe the requirements for materials or products, which can then be unambiguously interpreted by a bidder in the course of the tendering process and responded to by specific DataTemplates with information on specific products. The processing of this information can be largely automated, since DataTemplates are fully machine-readable. This advantage, combined with the automated collection of masses and quantities from the digital models, will change the interaction between planning, execution, industry, and logistics – the construction of a continuous data chain to building products will become a reality.

The interaction between DataTemplates and IFC-based digital models is still under development. Therefore, the integration of DataTemplates into BIM applications is still in preparation.



2.4 Organization

This section covers the BIM-relevant organizational topics of roles and service profiles, BIM rulebooks, collaboration in openBIM, and the IDM methodology including MVDs.

2.4.1 Roles and service profiles (LM BIM)

The conventional service specifications (e.g., HOA, LM.VM) currently do not contain any specific information regarding the basic services for the proper execution of a project with regard to BIM. Therefore, for BIM projects a definition of separate roles and service specifications (= service models LM BIM) is necessary. However, the roles (and also BIM organizational units) in the project must refer directly to BIM tasks and BIM services in order to retrieve them. The use of BIM performance models is not mandatory but recommended.

Established BIM service profiles (LM BIM) are currently freely available from buildingSMART Austria (see QR code). They are already in use in numerous BIM pilot projects of private and public clients.

The main objective of LM BIM is to create a uniform understanding between the client and the contractor of the scope of services to be provided

- for the basic interaction of the services,
- for the allocation of services to the respective BIM organizational units (roles),
- for the service to be provided by each BIM organizational unit (role), and
- for the general differentiation from existing, conventional services.

The medium-term goal of unified LM BIM is the creation of associated standard terms of compensation.

The LM BIM flow into the BEP via the EIR. They form the basis for the content of the topics of project management and implementation in the individual project phases (services of the client and contractor). A service profile always includes the classification of the respective organizational unit in the overall structure, the description of the general and cross-project-phase services, and the project-phase-related services.

The LM BIM can be customized on a project-by-project basis. This is done to

- increase the potential pool of bidders by lowering the requirements,
- reduce bid prices through prophylactic reduction of the scope of the services to be provided, and
- modify responsibilities due to changed project constellations.

The LM BIM describe the roles and services of the BIM organizational units. According to the definition of platform 4.0 (for Austria), these are:

BPL – BIM project management (AG): Qualification at the level of the owner. This is the responsible body at the AG for the general definition of the framework conditions of a project and the service profiles used by the respective actors, as well as for the enforcement of the AG's requirements for the data structure used in the project. The BPL creates the EIR.

BPS – BIM project management (AG): Qualification at the project control level. It represents the interests of the AG in the specification and operational implementation of a BIM project within the framework of the specifications of the BIM project management. The BPS prepares the BEP.

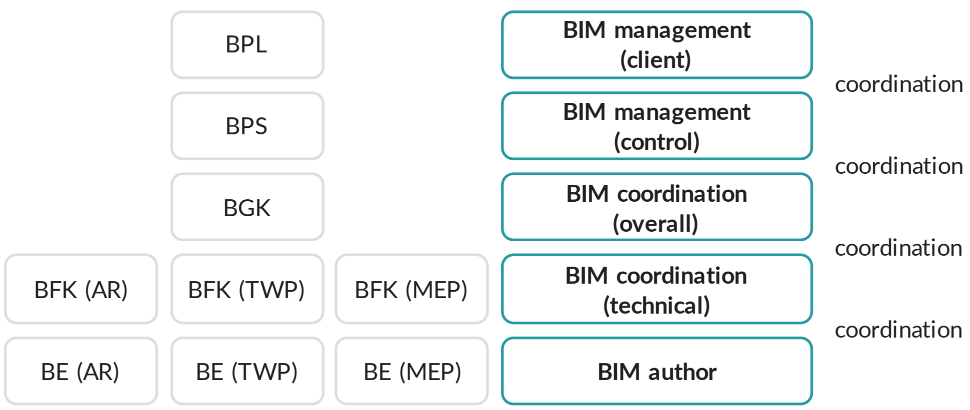
BGK – BIM-Gesamtkoordination (BIM overall coordination) (AN): Coordinates and verifies the interdisciplinary BIM content of the parties involved in the planning process based on the specifications of the BIM project control. It is responsible for the coordination model and monitors the execution of the specified tasks of the BIM specialist coordination. The BGK team is the primary contact for the digital planning vis-à-vis BIM project control.

BFK – BIM-Fachkoordination (BIM discipline coordination) (AN): Verifies the specialist discipline-specific BIM content of the respective planning teams.

BE – BIM-Erstellung (BIM designer) (AN): Acts as the creator of discipline-related model content.

BIM-ÖBA – BIM-Örtliche Bauaufsicht (BIM local construction supervision) (AN): Implements the specifications and organizes the corresponding technical setup on-site.

The corresponding BIM organizational units coordinate among each other:



Note: Sheet 2 of VDI 2552 defines the BIM organizational unit »BIM user«. This describes a project member who uses the models only to obtain information and does not add any data or information to the models.

The aim of the organizational structure is to clearly define contact persons, to show clear decision-making paths and a clear distribution of tasks.

To allow cooperation, the assessment of the BIM competence of all project participants involved over the life cycle of a project is required. The AG must analyze the BIM competence (qualification) of the project participants. The qualification of the organizational units should be confirmed at the beginning of the project by verifying competencies. The BPS determines this via

- questionnaires,
- proof of participation in training (organizational training and for software applications), and/or
- the specification of BIM project experience (across several project phases), i.e., project-specific assessments.

This helps to identify potential competence deficits and define training requirements. Only then can project responsibilities be defined.

2.4.2 BIM rules and regulations (EIR, BEP)

BIM rules and regulations form the basis of BIM projects. BIM rulebooks explain the relevant objectives of the AG, the requirements for the project participants, and the procedures for the successful implementation of these requirements. They also specify any supplements to the common project manuals, e.g., the OHB or project manual.

The application of BIM rules and regulations is highly recommended for projects of any size, regardless of the fact that this is not (yet) mandatory. The BIM rulebooks provide a clear regulation of the project organization, the project objectives, the specifications for project implementation, project management, the definition of cooperation, and quality assurance for BIM projects. These regulations are mostly missing in standard project manuals. BIM rulebooks (such as EIR) also help clients identify what information is necessary to achieve their project goals.

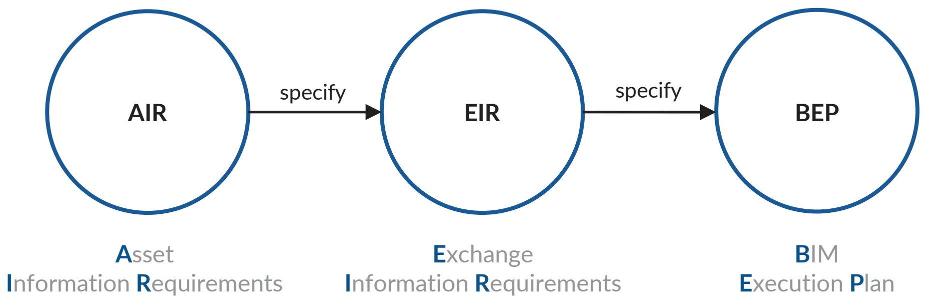
The currently established and freely available BIM rulebooks are the EIR and the BEP (see QR codes) released by bSAT/bSCH (2020).

The individual BIM rules and regulations are in accordance with the definition of the terms of platform 4.0 (for Austria):

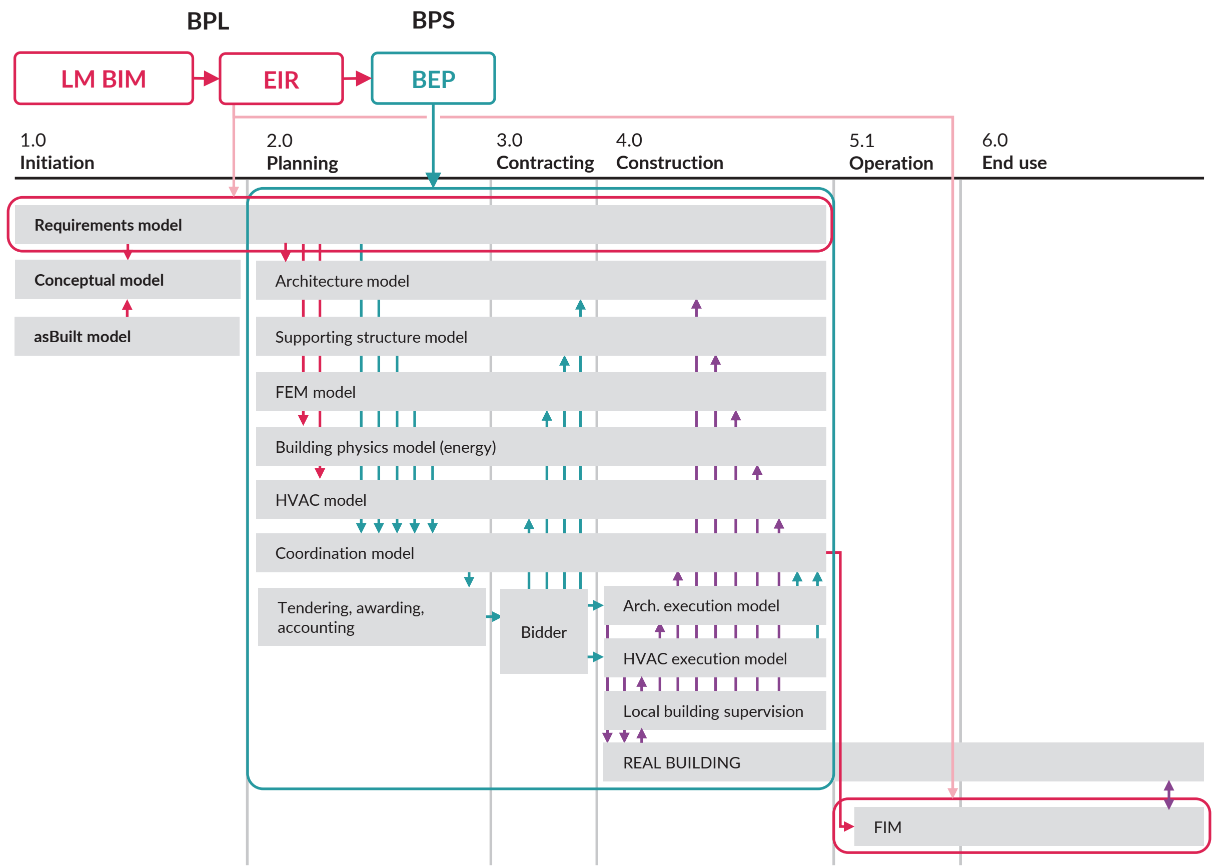
AIR – asset information requirement: The AIR defines the operator's long-term data structure and detail requirements based on data management. It determines the valid sources of information for the base estimation. The AIR is created independently of the project by the operator's BIM management and serves as a company-wide basis for the creation of project-specific EIR.

EIR – exchange information requirements: The EIR contain the description of the information needs of the client and are thus described as a requirement for the contractor. They serve as the basis for the BEP in a project. More specifically, the EIR contain the BIM requirements, BIM processes, and BIM software applications required to achieve the client's BIM objectives.

BEP – BIM execution plan: The BEP is a policy document that defines the basis of a BIM-based collaboration. It specifies the organizational structures and responsibilities. The BEP provides the framework for the BIM deliverables and defines the processes/workflows and the collaboration requirements of the individual participants. The models and processes are standardized in terms of structures, elements, and information. The BEP also specifies the project-specific characteristics and defines the level of information and detailing and their qualities. The BEP should become part of the contract between the client and the project participants.



Section 2.5 contains further information on standardized information requirements according to ISO 19650, Parts 1, 2, and 3.



Hierarchically, the AIR are above the EIR – they flow into the EIR. The EIR specify the information requirements of the client beyond the AIR. Based on the EIR, the BEP also contains the AIR and serves as a set of project rules. In BIM projects, the BEP is to be applied from the start of planning to the completion of construction or handover and operation.

The topics of the EIR and BEP include:

- **Project information:** Summary of the AG's content specifications (e.g., times/milestones for information transfer)
- **General requirements:** Summary of the normative specifications of the AG (e.g., standards and guidelines to be adhered to, required file formats including versioning)
- **Model-specific specifications:** Definition of model structure and intended development stages
- **Project organization:** Definition of the organizational levels and associated service profiles (responsibilities)
- **Use cases:** Specifications for the use of model data, such as uniform model checking or cost determination
- **Annexes:** In-depth description of individual aspects (e.g., technical guidelines such as the definitions of LOG and LOI)

Attention must be paid to the following: The EIR predefine the content of the topics and the BEP formulates these specifications. Thus, the BEP (according to ISO 19650) also contains the assignment of names/competencies to the individual roles as well as the information delivery strategy for the procedure and for the compliance with the required exchange information. The BEP therefore also defines the quality control.

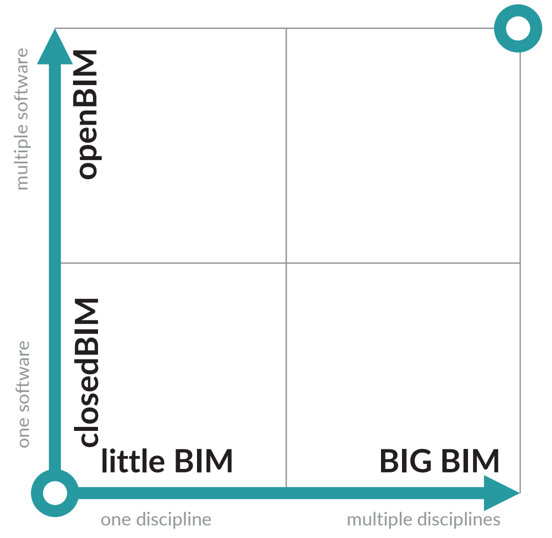
At the beginning of the project, a colloquium about the BEP should be held with all key project participants. In this meeting, the content and scope of the tasks are explained and agreed upon. Such a colloquium promotes successful cooperation in the project.

2.4.3 openBIM collaboration

The advantages of the BIM method should be exploited fully, not only technically but also structurally. Therefore, the use of the openBIM method is recommended for all projects. In terms of implementation and collaboration, the advantages are as follows:

- software independence and freedom of choice for software applications for all project participants (no competitive disadvantage regarding software applications),
- long-term usability of model data (sustainability through ISO certification of IFC and the IDM), and
- autarky of software-specific model information (transparency).

The development stages of BIM provide a clear classification:

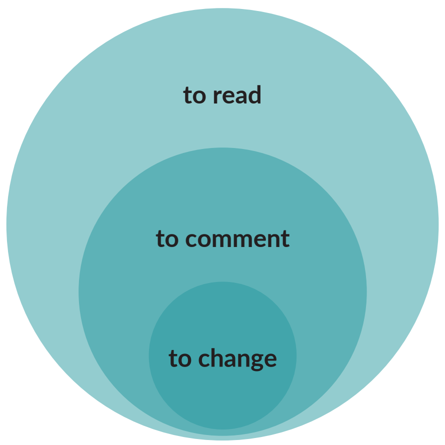


- little BIM: BIM island; BIM used only in isolated disciplines
- BIG BIM: BIM integration in all disciplines
- closedBIM: closed solution, use of one software (family)
- openBIM: open solution; interchangeability across different BIM-enabled software products

The free choice of software supports the use of the most suitable software for the respective task (best practice).

The application of the openBIM method is also promoted by standardisation. For example, ÖNORM A 6241-2 creates the basis for a comprehensive, uniform, product-neutral, systematized exchange of graphical data and the associated factual data on the basis of IFC and the bSDD.

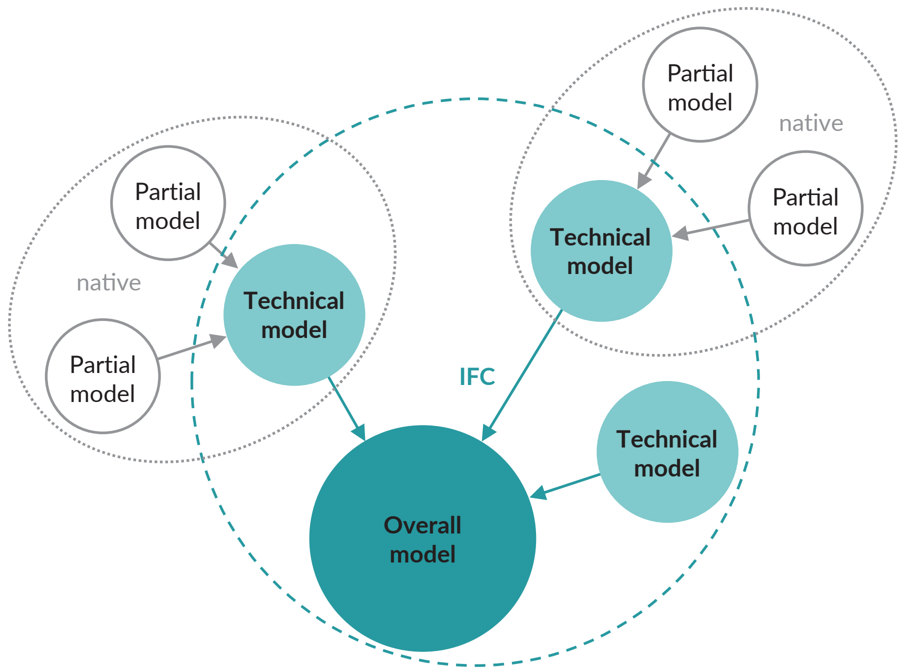
The BEP regulates the form of structured cooperation, for example by specifying the interfaces, which also include the MVD. The prerequisite is the use of software certified by buildingSMART. An essential aspect of data exchange is interoperability: the secure transmission of the object information of the models must be guaranteed.



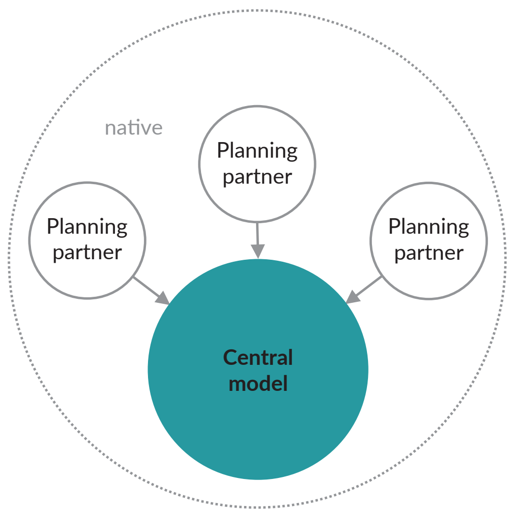
BIM models must

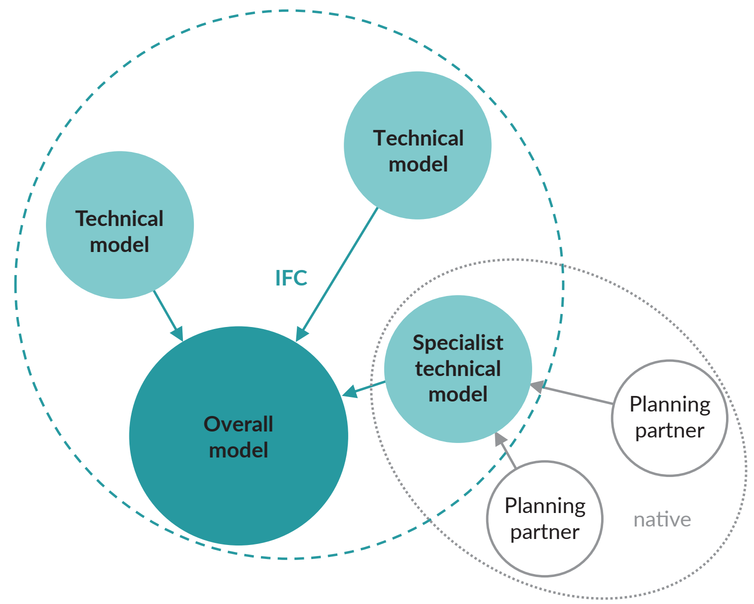
- be readable for all,
- allow many to comment, and
- allow a few to make changes.

Model-based collaboration not only concerns quality management in the overall model, but also (first) collaboration at the model level. According to openBIM, each specialist planner who supplies model data creates it in his own software application (authoring software) as a domain model. Due to its data size, this can consist of partial models, all created in the same (native) software application. The exchange of domain models takes place via the IFC interface. All domain models then flow together in the overall model.



In contrast exists the system of a central model in which all specialist planners work together on a central model using one software application (software family). This is referred to as closedBIM. Mixed forms are also possible. A specialist planner can work together with his planning partners in closedBIM, but operate the overall model for coordination based on openBIM via IFC.





Quality management and the coordination of domain models in the overall model should always take place in a separate software application (checking software) which checks and evaluates the model data independently. Communication takes place digitally. Problem points are always transmitted in report form. This is done in PDF for documentation purposes and in BCF to allow the specialist planners to see the problem directly in their software applications.

Like all project communication, the exchange of model data and reports (in PDF and BCF) takes place via the CDE provided for this purpose.

2.4.4 IDM Methodology

The exchange of models and model information between organizational units requires technically well-defined descriptions, terminology, and interfaces. This also includes the IDM and the MVD.

The interaction between the IDM and the MVD is described in this section.

IDM – information delivery manual:
The IDM methodology supports the description of information requirements related to processes within the life cycle. IDMs have been developed by buildingSMART and certified as ISO standards (ISO 29481-1 and ISO 29481-2). These standards harmonize the creation and structuring of use cases.

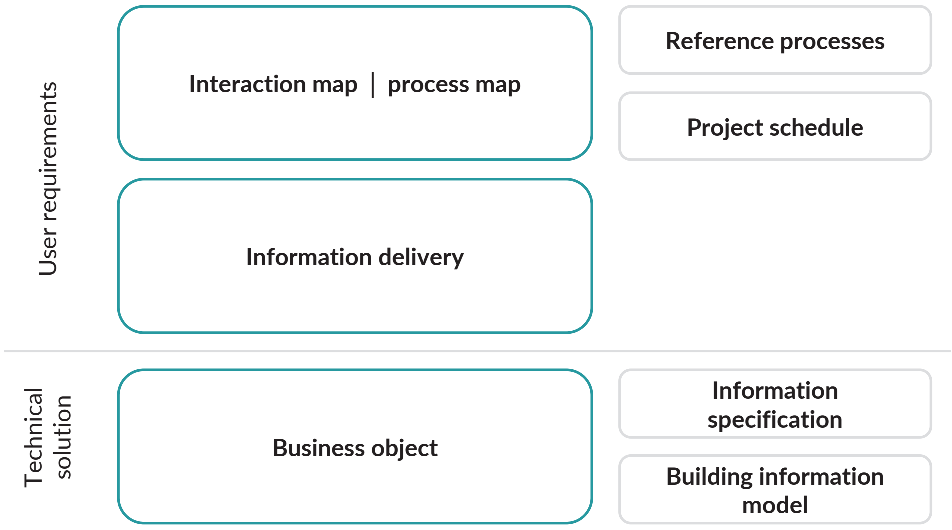
IDMs are created by using BPMN, the so-called process modeling. buildingSMART provides templates for the creation of IDMs (see QR code).

IDMs are used primarily by technical users and software developers. They use the following approach:

- What additional inputs are needed?
- What does the originator supply, what is required by the recipient?
- Representation in a document and in a flowchart.

An IDM thus defines the scope and type of an information request that is required or that must be supplied by dedicated BIM organizational units (roles) at a specific point in time (process) (exchange requirements). The description of an efficient exchange in the form of an IDM is very important because the relevant data transmitted must be communicated in a way that the receiving software can interpret the data correctly.

ISO 29481-2 defines IDM zones with respect to user requirements and technical solution:



In the interaction between the individual ISO and buildingSMART standards, the IDM fulfills the task of accurately describing the defined processes for an MVD (IFC schema) using the bSDD and thus rendering them applicable.

MVD – model view definition:
The processes defined in an IDM are translated into concrete technical requirements in so-called MVDs. They represent a process-related subset of the entire IFC schema. MVDs describe the data exchange for a specific use or a specific workflow (specific data exchange requirements).
MVDs can be

- as wide as almost the entire schema (e.g., for archiving a project) or
- as specific as a few object types and associated data (e.g., for pricing a facade system).

They provide guidance for all IFC expressions (entities, relationships, attributes, and properties, property sets, set definitions, etc.).

An MVD can define an application-specific view for each project engineer and thus specify a subset or filtered view of the IFC (for example, a limited element or data set). This defines »what« and »how« should be passed. Similar to IFC in XML, a MVD is machine-readable by mvdXML.

Documenting an MVD allows the exchange of these data to be repeated and provides consistency and predictability across a variety of projects and software platforms.

BIM rulebooks (EIR and BEP) refer to MVDs in the data formats to be used and in the transfer configuration specifications. The most common MVDs are:

IFC2x3 – coordination view (CV2.0): Spatial and physical components for design coordination between the fields of architecture, structural engineering and building services engineering (MEP)

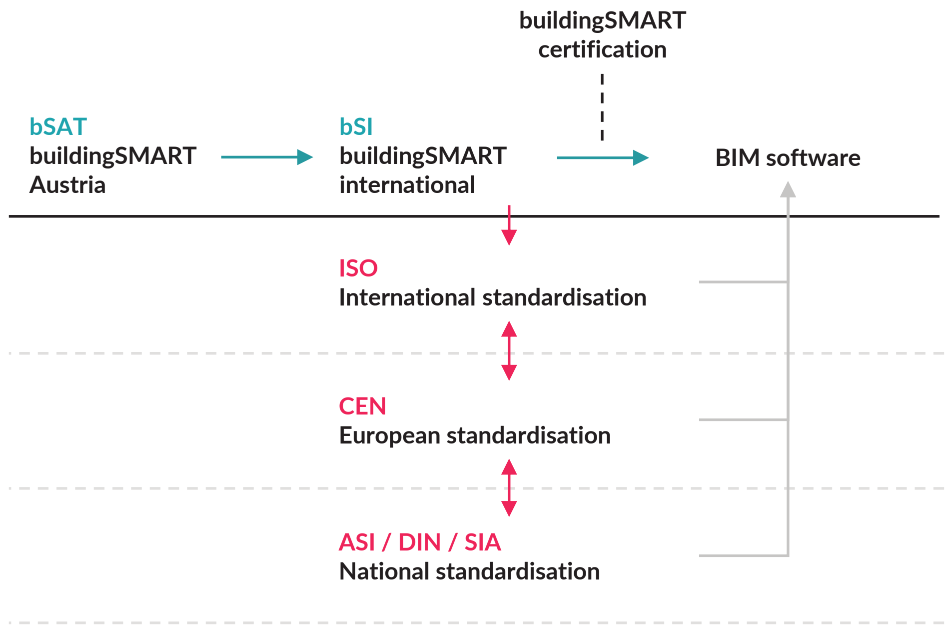
IFC4 – reference view (RV): Simplified geometric and relational representation of spatial and physical components to reference model information for design coordination between the architectural, structural, and building engineering domains.

IFC4 – design transfer view (DTV): Advanced geometric and relational representation of spatial and physical components to allow the transfer of model information from one tool to another. It is not a »back-and-forth« transfer, but a more accurate one-way transfer of data and responsibility.

The MVD, in interaction with the other ISO and buildingSMART standards, permits the application of the process specifications of an IDM using subsets of the IFC data structure to transport the required data using the bSDD.

2.5 Standardisation

Today there are over 6,500 different languages in the world. The exchange of information within the same language (closed) is easier than between different languages (open). In order to exchange information between the individual languages without major loss of information, many countries have agreed on a standard to be used – e.g., the language »English«. The openBIM method assumes a platform-neutral exchange of data. Thus, the implementation of the openBIM method requires clear and open standards so that information losses during information exchange are minimized. This section provides an overview of national, European, and international standardisation efforts.



2.5.1 International standardisation

As an independent association, bSI develops its own standards. The best known are the IFC and the BCF. The object-oriented specification for IFC was first published in 1995 as IFC1. The current version, IFC4, was officially published in March 2013 as ISO 16739 and is being continuously developed. The current version is IFC4 ADD 2 TC1. The ISO certification guarantees the sustainable usability of the model data. The certification of a software product does not apply to the entire IFC data structure but to a specific model view definition (MVD).

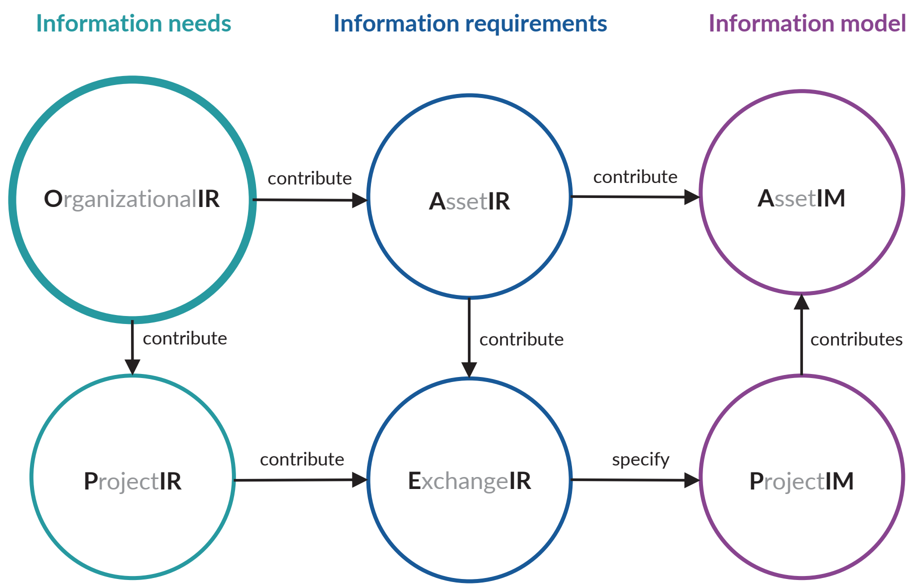
In addition to the data structure, bSI is developing the international property server bSDD, which allows the international exchange of product information. The bSDD is based on ISO 12006-3, which defines the IFD. The IFD (International Framework for Dictionaries) is a framework for defining classification systems. Its basic principle is that all concepts can have a name and a description (regardless of language). However, only a unique identification code is utilized for identification and use. By attaching labels in multiple languages to the same concept, a multilingual dictionary is created.

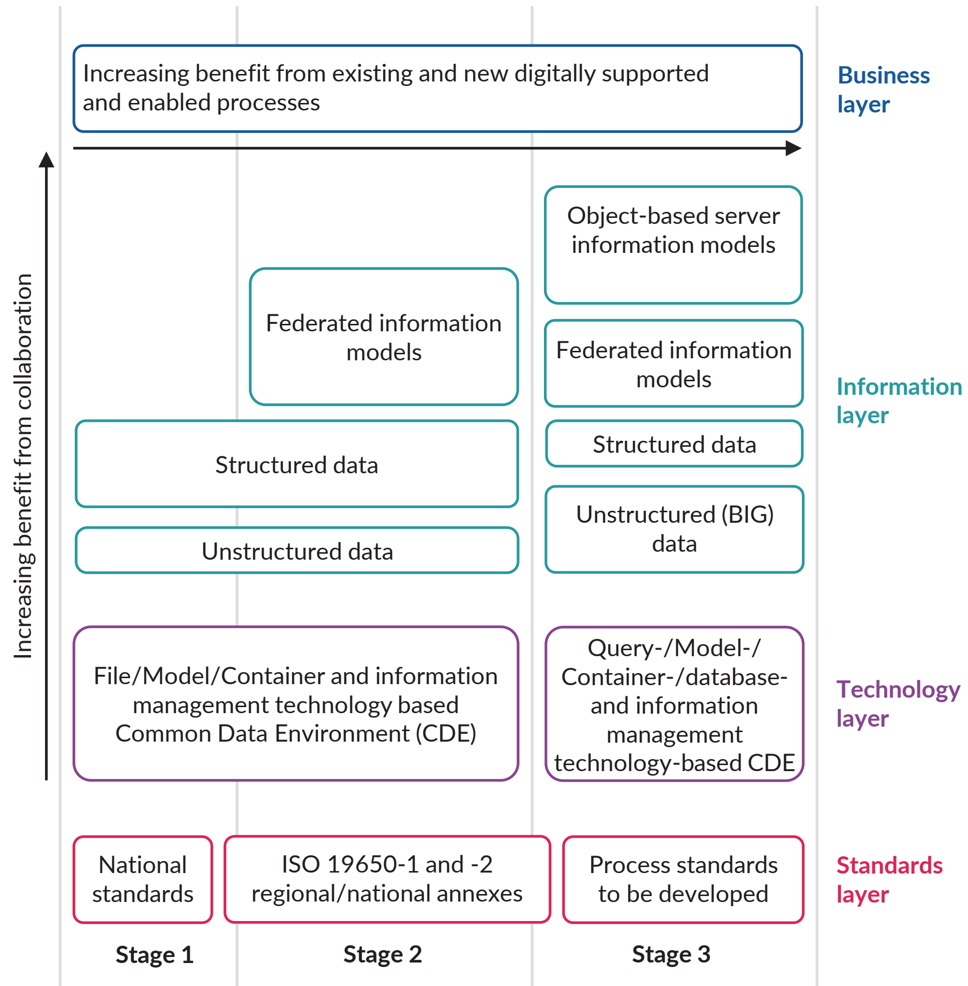
ISO 19650 Parts 1, 2, and 3 are process specifications that define BIM services and their implementation. According to ISO 19650, a distinction is made between the following BIM maturity levels (»BIM stages« in ISO 19650) and the respective development stages of information management:

- BIM stage 1: Combination of 2D CAD planning and 3D models as the standard for the planning of construction projects
- BIM stage 2: The universal application of ISO 19650 for the planning of construction projects
- BIM stage 3: openBIM as the standard for the planning of construction projects

In ISO 19650, two time periods are defined, each with its own model. The project information model (PIM) is used during the planning and construction phases. The asset information model (AIM) is used during the operational phase. Both models contain both geometric and alphanumeric information. The models have different requirements that influence each other:

- organizational information requirements (OIR),
- project information requirements (PIR),
- asset information requirements (AIR), and
- exchange information requirements (EIR).





2.5.2 European standardisation

In 2015, the standardisation body CEN/TC 442 »Building Information Modeling (BIM)« was established at the European level. The committee develops a structured set of standards and reports. The aim is to establish the methodology for defining, describing, exchanging, monitoring, and recording asBuilt data (»asset data«), as well as for the safe handling of such data, semantics, and processes with the corresponding links to geodata and other external data.
This technical committee consists of four working groups:

- »Strategy and planning« (Secretariat Great Britain)
- »Exchange information« (Secretariat Germany)
- »Information delivery specification« (Secretariat Austria)
- »Data dictionary« (Secretariat France)

Austria chairs the information delivery specification working group, which is dedicated to the central question: »Who delivers what, when, and in what quality, and who has to check it?«

2.5.3 National standardisation

The national standards for digital modeling are summarized in the separate digital standards group ÖNORM A 6241.

ID	Designation	Status
ÖNORM A 6241-1:2015	Digital Building Documentation – Part 1: CAD-Data Structure and Building Information Modeling (BIM) – Level 2	published
ÖNORM A 6241-2:2015	Digital Building Documentation – Part 2: Building Information Modeling (BIM) – Level 3-iBIM	published
ÖNORM A 6241-3	Digital Building Documentation – Part 3: Building Information Modeling (BIM) – BIM-based Computer Aided Facility Management (CAFM)	edited
ÖNORM A 6241-4	Digital Building Documentation – Part 4 : Building Information Modeling (BIM) – Building Automation	edited
ÖNORM A 6241-10	Digital Building Documentation – Part 10: Building Information Modeling (BIM) – Definitions and Basic Concepts	edited

The ASI summarizes the contents of their standards as follows:
ÖNORM A 6241-1 regulates the technical implementation of data exchange and the data management of building information of structural engineering and related space-forming constructions of civil engineering, which are required during the planning and for the life cycle management of real estate, including the alphanumeric data contained in these building models. This ÖNORM further contains the most important terms, structures, and representation bases. It specifies the basic techniques of data transfer of two-dimensional CAD files and for BIM.
ÖNORM A 6241-2 regulates the technical implementation of a uniform, structured multidimensional data model for building structures and related space-forming civil engineering structures, based on building information modeling level 3-iBIM. This ÖNORM also lays the foundations for a comprehensive, uniform, product-neutral, and systematic exchange of graphical data and the associated factual data based on IFC and the bSDD.

While ÖNORM A 6241-1 defines the general exchange of CAD files between project participants, ÖNORM A 6241-2 defines the basics for an openBIM data exchange based on IFC and the bSDD. The ÖNORM A 6241-2 is divided into the following chapters:

- Terms
- Project model
- Life cycle phases of a building (ÖNORM EN 16311)
- Dimensions
- Levels of detail
- IFC (including ASI feature server)

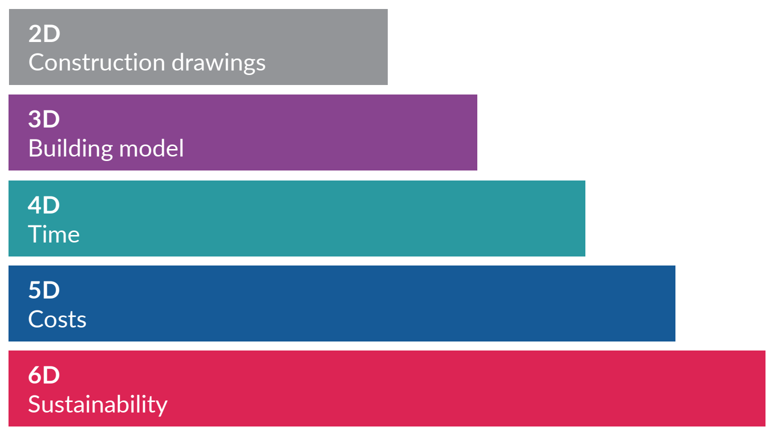
The appendix further includes a rudimentary modeling guide, the mapping of life phases to other known standards, levels of detail, project phases, and a BIM workflow.

ÖNORM A 6241-2 describes the ASI feature server. This is a kind of national feature server. The definition of characteristics including description, discipline affiliation, type, project phase, etc. takes place in the ASI feature server. These characteristics are linked to the international feature server (bSDD) by means of bSDD-GUIDs.

The description of the billing of services is of great importance for the AVA process. The standard points out that billing can be done via models rather than according to the work contract standards if it is contractually agreed beforehand.

The term »dimension« is also introduced in ÖNORM A 6241-1. This is intended to describe the handling of the virtual building model data in a project based on the factors of time, cost, and sustainability:

- 3D – building model: Presence of geometric and alphanumeric information in a building model
- 4D – time: Based on the model information, the construction schedule is determined/simulated.
- 5D – costs: Quantities and costs are determined semiautomatically in accordance with ÖNORM A 2063 with the help of standardized specifications. ÖNORM A 6241-1 points out that the quantity determination does not have to be carried out according to work contract standards. If an appropriate agreement between the client and the contractor exists, the quantity determination can be carried out based on the model.
- 6D – sustainability: Based on the model information, an assessment is made with regard to environmental, social, and economic issues.



3 Advanced knowledge

This chapter provides an in-depth insight into the IFC data schema. A sound understanding of IFC is essential for the extensive use of openBIM. This is followed by a more detailed examination of the model view definition, the common data environment, and levels of detail, and by an overview of the interrelationships of standardisation. The contents of this chapter provide the foundation for the descriptions of the openBIM project implementation presented in Chapter 4.

- Relevant for BIM newcomers, BIM practitioners and BIM experts who want to go into more detail on the technical details for comprehensive openBIM deployment.
- Relevant for all those who want to take the BIMcert practitioner certification exams (equivalent to »Professional Certification – Practitioner«).
- Prior knowledge of the contents of Chapter 1 and Chapter 2 is assumed.

Sources and recommended reading

Borrmann A., König M., Koch C., and Beetz J. (eds.): »*Building Information Modeling: Technologische Grundlagen und industrielle Praxis*«. Springer Fachmedien, Wiesbaden, 2015, ISBN: 978-3-658-05606-3. In German.

Borrmann A., König M., Koch C., and Beetz J. (eds.): »*Building Information Modeling: Technology Foundations and Industry Practice*«. Translated and extended from the German version, Springer International Publishing AG, Cham, 2018, ISBN: 978-3-319-92862-3 (see QR code).

Hausknecht K. and Liebich T.: »*BIM-Kompendium – Building Information Modeling als neue Planungsmethode*«. Fraunhofer IRB Verlag, Stuttgart, 2016.
(2nd edition announced to be released in October 2021: https://www.baufachinformation.de/bim-kompendium/buecher/247752). In German.

Ratz L., Schranz C., and Urban H.: »*Industry Foundation Classes und deren Anwendung in openBIM-Projekten*«. Report, Centre for Digital Building Processes, TU Wien, 2020. In German.

Scherer R. J. and Schapke S.-E. (eds.): »*Informationssysteme im Bauwesen 1: Modelle, Methoden und Prozesse*«. Berlin, Heidelberg, Springer-Verlag Berlin Heidelberg, 2014, ISBN: 978-3-642-40882-3. In German.

Important abbreviations appearing in this chapter are:

ADD	Addendum
BCF	BIM collaboration format
BEP	BIM execution plan
bSDD	buildingSMART data dictionary
bSI	buildingSMART International
CDE	Common data environment
CEN/TC	Comité Européen de Normalisation / Technical Committee
CV	Coordination view
DTV	Design transfer view
EIR	Exchange information request
EN	European standard
FIM	Facility information model / Facility information management
GUID	Globally unique identifier
IAI	Industry Alliance for Interoperability / International Alliance for Interoperability
IDM	Information delivery manual
IFC	Industry foundation classes
ISO	International Organization for Standardisation
LOC	Level of coordination
LOD	Level of development
LOG	Level of geometry
LOI	Level of information
MVD	Model view definition
PAS	Publicly available specification
QA	Quality assurance
QC	Quality control
QV	Quantity view
RC	Release candidate
RV	Reference view
STEP	Standard for the Exchange of Product Model Data
TC	Technical corrigendum

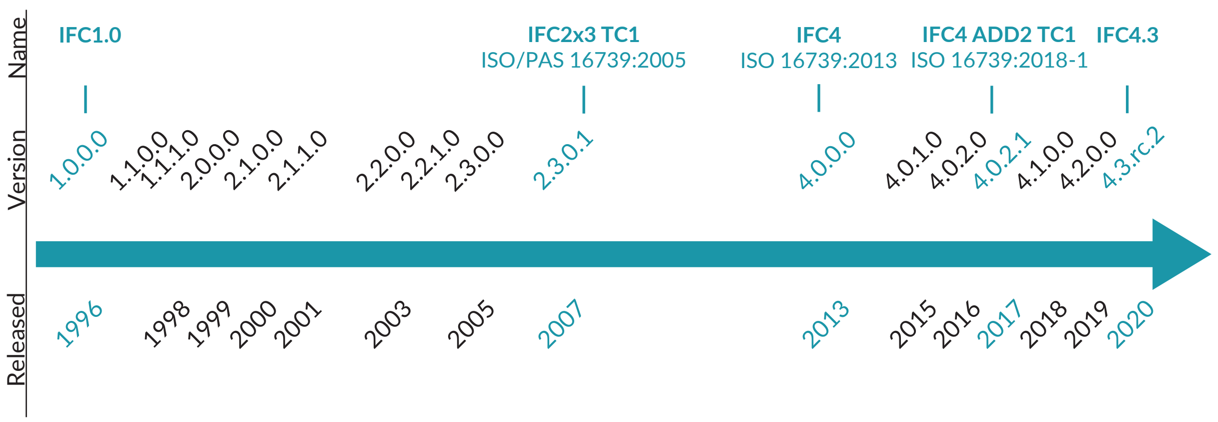
3.1 IFC – industry foundation classes

This section describes in detail the IFC data structure – an essential basis for the exchange of digital building information. IFC are both a data structure and a data format for building data. Further to the general basics, essential terms are defined. This is followed by an explanation of the data schema architecture and the basic modeling concepts, namely conceptual layers, inheritance hierarchies, domains, element classes, relationship mappings, attributes, properties, and object types.

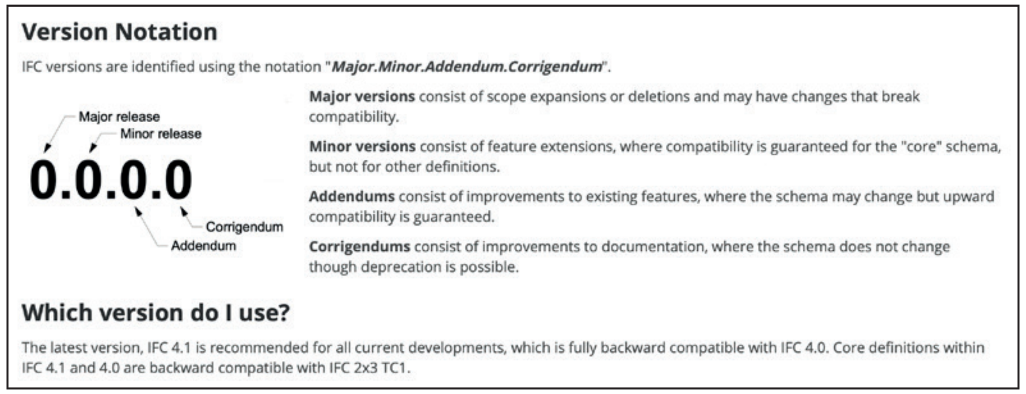
3.1.1 General principles

This subsection provides insight into the origins and development of IFC, its underlying data modeling language and common file formats.

In the 1980s, in an effort to create uniform interfaces between heterogeneous CAD systems, the standardisation framework »STEP – Standard for the Exchange of Product Model Data« was defined in the ISO 10303 standard. In the mid-1990s, a group of engineering firms, construction companies, and software manufacturers, with Autodesk, Bentley, and Nemetschek playing a major role, joined forces to form the International Alliance for Interoperability (IAI), which was renamed »buildingSMART« about ten years later. Their ambition was to make the standardisation of the building industry more efficient. In 1996, they published the first version of the Industry Foundation Classes: IFC1.0. Software vendors implemented the standards in their products, which buildingSMART published free of charge and vendor-neutral, independent of ISO certifications. In 2007, the version IFC2x3 TC1 was released, which was the first version to receive ISO certification. The current, fourth version (IFC4) was released in 2013 and certified as ISO standard ISO 16739:2013 »Industry Foundation Classes (IFC) for Data Interchange in Construction and Facilities Management«. The current, ISO-certified version of IFC is IFC4 ADD2 TC1. The most recent version, IFC4.3, still carries the status »Release Candidate 2« in 2021. All IFC versions released so far can be found in the »IFC Specifications Database« of buildingSMART and are shown in the following figure.



Over the course of the time period since the release of IFC1.0, buildingSMART used different official notations or version identifiers, e.g., IFC2x3 or IFC4. However, at the buildingSMART Summit 2019 in Düsseldorf, buildingSMART introduced a new (permanently stable) version notation (designation logic). This notation is now in force and can be found on the buildingSMART website (see QR code):



Version Notation

IFC versions are identified using the notation "***Major.Minor.Addendum.Corrigendum***".

Major versions consist of scope expansions or deletions and may have changes that break compatibility.

Minor versions consist of feature extensions, where compatibility is guaranteed for the "core" schema, but not for other definitions.

Addendums consist of improvements to existing features, where the schema may change but upward compatibility is guaranteed.

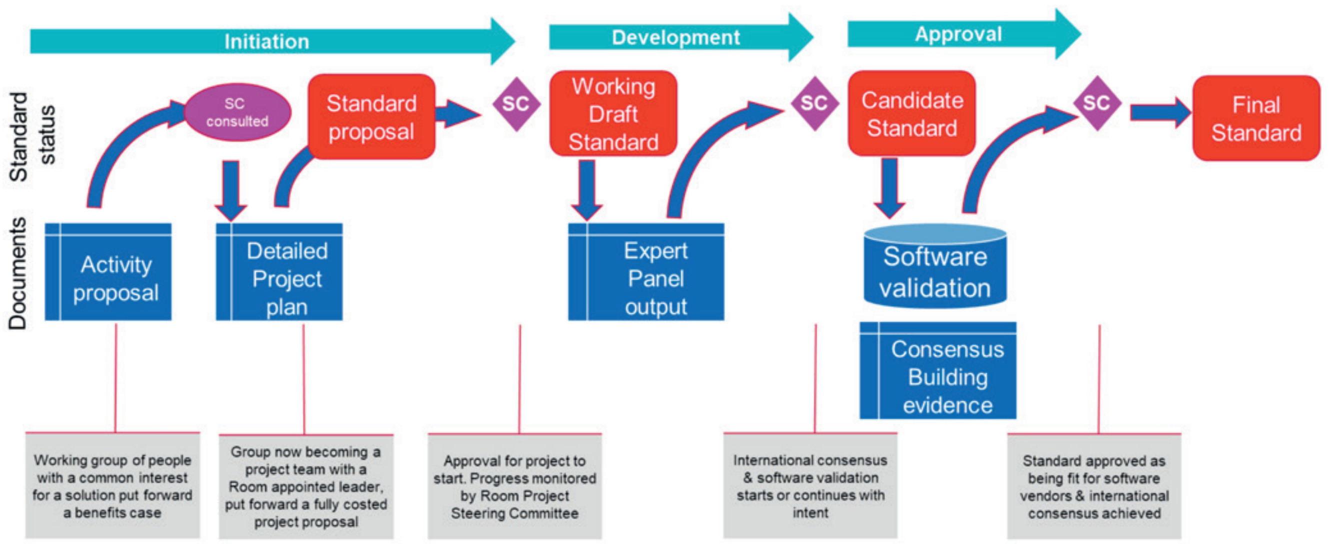
Corrigendums consist of improvements to documentation, where the schema does not change though deprecation is possible.

Which version do I use?

The latest version, IFC 4.1 is recommended for all current developments, which is fully backward compatible with IFC 4.0. Core definitions within IFC 4.1 and 4.0 are backward compatible with IFC 2x3 TC1.

The notations of the versions are composed of four digits that stand for ***»Major. Minor.Addendum.Corrigendum«***. If the first digit changes, there are major changes (***Major***), which can affect the compatibility with former versions. A new *major version* can generally be expected every ten years. Such a version includes a fundamental developmental leap, for example the inclusion of all infrastructure components in IFC5 (5.0.0.0). In the case of minor changes (***Minor***), the compatibility of the »core« schema with former versions is guaranteed. Minor versions are therefore intermediate steps toward the integration of new functionalities, the inclusion of the *IFC alignment* in IFC4.1 (4.1.0.0), for example. An ***addendum*** can contain selective improvements for existing functions, e.g., the introduction of NURBS surfaces for BREP transfer in IFC4 Add2 (4.0.2.0). Upward compatibility is guaranteed. With a ***corrigendum***, the schema is not changed, but functions can be invalidated (*deprecated*). Adjustments/corrections to the documentation are also corrigenda, e.g., the improvement of the EXPRESS schema in IFC2x3 TC1 (2.3.0.1)

New developments of a minor version are released in a standardized, multistage procedure (project delivery governance; see QR code) as release candidates, e.g., 4.3.rc.1) (see following figure).



Currently, the most widely used version is IFC2x3, which is, however, to be replaced progressively by IFC4. In this book, reference is generally made to the latest IFC specification (IFC4.2) (see QR code for documentation).

Already, IFC is the basis for the realisation of openBIM, in particular for initiatives in the government sector whose goal is the mandatory application of BIM in public construction projects. The IFC standard contains definitions for data that is relevant for buildings over their entire life cycle. In addition, the scope of the data definitions is currently being extended to infrastructure assets.

IFC specifies a data schema and a file format. IFC4.2 describes the data modeling language underlying the data schema and the applicable file formats. The IFC data schema is based on the EXPRESS data modeling language, which is governed by Part 11 of the STEP standard (ISO 10303-11). In addition to the textual notation, the standard defines a graphical notation (EXPRESS-G) to represent the data. The documentation of the IFC4.2 data schema contains illustrations created using EXPRESS-G. In place of EXPRESS, the data modeling language XML defined in ISO 10303-28 can also be used, with the XML notation derived from the EXPRESS notation. In a presentation, Prof. Rasso Steinmann refers to this EXPRESS schema as a cake form that does not yet describe concrete instances of the data model. Various file formats are available for the exchange of model data. buildingSMART recommends the use of the SPF (STEP Physical File) format, which is defined in ISO 10303-21. The file extension is ».ifc«. This format is also available in a compressed version, where the IFC file is compressed using a ZIP container. The file extension is ».ifczip«. In addition, there is also the aforementioned XML file format with the extension ».ifcXML« (see QR code), which carries model data less compactly than ».ifc« and is currently hardly used.

An IFC file can be opened by any text editor. Each IFC file consists of a HEADER section and a DATA section. The HEADER section contains information about the model view definition, the file name and path, the author, the software used, and the IFC schema used for the export. A HEADER section can look as follows:


```
ISO-10303-21;
HEADER;FILE_DESCRIPTION(('no view'),'2;1');
FILE_NAME(
'C:\\Users\\Linda\\Allplan Testprojekt\\TestprojektW\X2\00E4\X0\nde.ifc',
'2020-02-16T11:20:17',('Linda'),('Nemetschek AG',
'Konrad-Zuse-Platz 1, 81829 Munich / Germany'),
'EDMsix Version 2.0100.09 Sep 7 2016',
'Allplan 2019.1 24.06.2019 - 16:10:06','');
FILE_SCHEMA(('IFC4'));
ENDSEC;
```

In this example, a building model was created with Allplan 2019-1 and exported using the integrated IFC interface, where the IFC4 schema was selected. As a second option, export with the IFC2x3 schema can be chosen, which is currently more widespread and for which Allplan has been certified.

The DATA section contains information about the project. Each instance (see Section 3.1.2) is given a file-internal identifier in the STEP physical file format, which consists of a number preceded by a hashtag (#). A section of a DATA section can look as follows:

```
#347= IFCCARTESIANPOINT((0.,0.));
#349= IFCCARTESIANPOINT((10000.,0.));
#352= IFCRELASSOCIATESMATERIAL(‚3CStp9Q6j9PfrLpnWPTT4W‘,#11,$,$,(#386),
#383);
#353= IFCMATERIALLAYERSET((#355,#369),$,$);
#355= IFCMATERIALLAYER(#356,100.,$,$,$);
#356= IFCMATERIAL(‚Graphic hard‘,$,$);
#357= IFCPRESENTATIONSTYLEASSIGNMENT((#359,#167));
#359= IFCCURVESTYLE($,#117,$,#118,$);
#360= IFCSTYLEDITEM($,(#357),$);
#362= IFCSTYLEDREPRESENTATION(#61,$,$,(#360));
#364= IFCMATERIALDEFINITIONREPRESENTATION($,$,(#362),#356);
#369= IFCMATERIALLAYER(#370,300.,$,$,$);
#370= IFCMATERIAL(‚C25/30‘,$,$);
#371= IFCPRESENTATIONSTYLEASSIGNMENT((#373,#119));
#373= IFCCURVESTYLE($,#117,$,#118,$);
#374= IFCSTYLEDITEM($,(#371),$);
#376= IFCSTYLEDREPRESENTATION(#61,$,$,(#374));
```

3.1.2 Definitions

The following definitions of terms refer to the definitions of the IFC4.2 specification (see QR code) as well as definitions and translations from the bSDD.

Class, also referred to as **entity, element class, entity type**:
According to the IFC definition, an entity is an information class defined by common attributes and constraints, as specified in ISO 10303-11. Attributes as well as relationships to other entity types are defined for each entity type. The ob-

ject-oriented concept of inheritance is implemented. This passes attributes and relationships to subtypes.

Object and instance, also referred to as ***specimen, entity instance:***
An object is a tangible or imaginable object that can exist physically (like a wall) or be purely conceptual (like a load, a room, or a task). In the object-oriented modeling approach used in IFC, an object is also referred to as an instance or copy of a class. The class represents a kind of template for the creation or instantiation of objects. It thus describes the structure and behavior of similar objects.

Object type:
Similar to the class, an object type is also a kind of template that combines common characteristics of several instances. However, certain basic parameters that remain the same for repeating components are defined before the actual instantiation. A detailed explanation can be found in Section 3.1.10.

Attribute, also referred to as **parameter**:
According to the IFC definition, an attribute is a unit of information within a class. There are three types of attributes: direct, inverse, and derived attributes. Attributes are a way of statically defining properties for classes in IFC. This is explained in more detail in Section 3.1.9. Dynamic properties provide another option. Attributes are not set up by the modeler but created automatically by the software, such as the quantities described below.

Quantity:
A quantity is a key parameter deriving from the physical properties of an object such as a room or a building component. Measurement units for quantities include length, area, volume, weight, number, and time.

Property:
A property is a unit of information that is dynamically defined as an entity instance of the IfcProperty class. It can be used to describe the nature of an object.

Property set:
The IfcPropertySet is a container that carries properties in a property tree structure. Some predefined property sets are included in the bSDD. In addition, any user-defined property set can be captured. A more detailed explanation can be found in Section 3.1.9.
In addition to the already existing specifications, the IFC data structure allows the definition of individual supplements. These can be defined project-specifically in a local framework (e.g., with a data structure tool) and are communicated to the project team (using the EIR) or consolidated (using the BEP) via BIM rules. The following naming convention exists for such additions (see QR code):

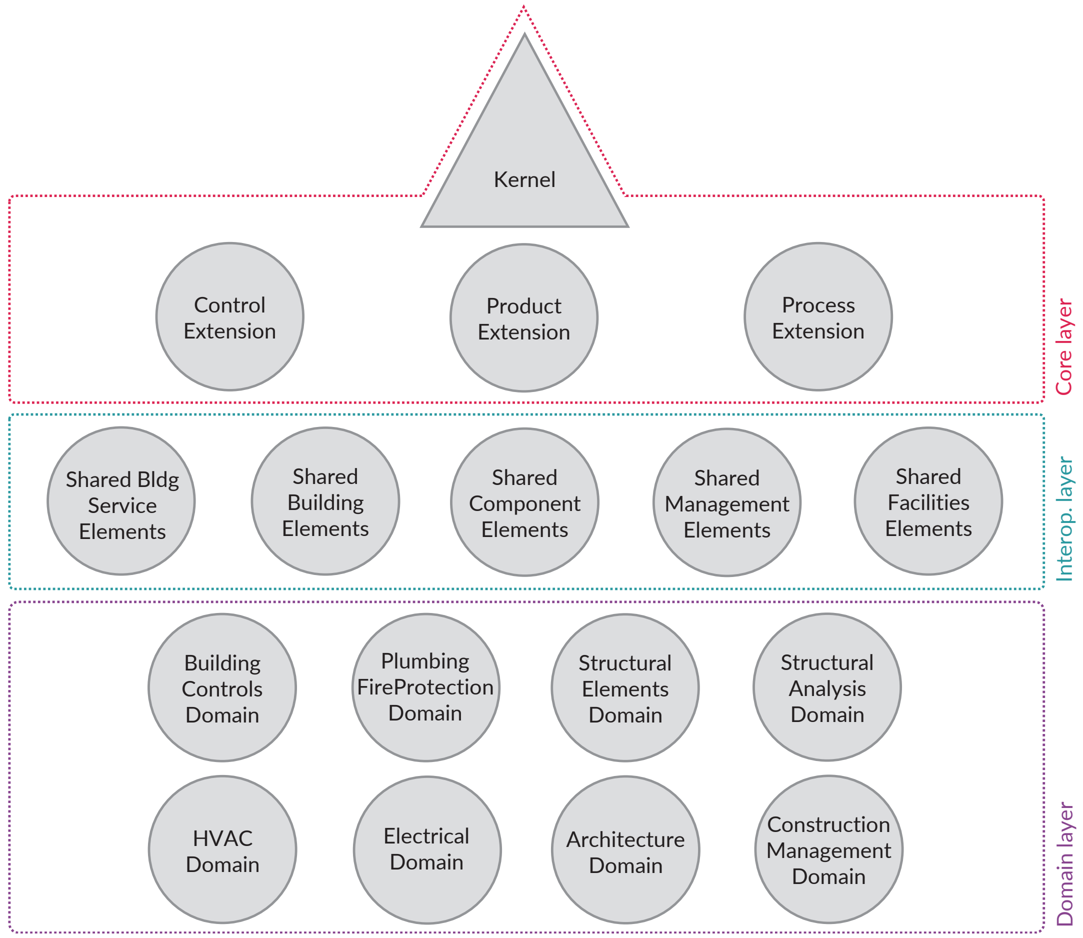
- Types, classes, rules, and functions have the prefix »Ifc«.
- Attributes of classes have no prefix.
- Property sets that are part of the IFC standard have the prefix »Pset_«.
- Quantity sets that are part of the IFC standard have the prefix »Qto_«.

The names of these data types are composed of English words concatenated without any space between them (CamelCase). The first letters of the words are capitalized and there is no underscore between the words. An example of this notation is OwnerHistory.

3.1.3 Conceptual layers

The IFC data schema architecture defines four conceptual layers, where each schema is assigned to exactly one of these layers (see previous QR code for the naming convention). The graphic on the following page shows the first three layers. The four conceptual layers are:

1. ***Core Layer:***
   This first layer contains the most basic classes of the data model. They can be referenced, i.e., reused and concretized, by classes of the interoperability layer and the domain layer. Basic structures, fundamental relationships, and general concepts are defined here. All classes of the three layers shown in the following figure have a GUID (globally unique identifier) and can also have an owner and a history (see Section 3.1.4).



The core layer consists of the kernel (core) and the three core extension subschemas (extension schemas) which are used to group basic entities:

- The kernel contains the most abstract class IfcRoot, which is the superclass of all classes of the first three layers. Direct subclasses of IfcRoot are IfcObjectDefinition, IfcPropertyDefinition, and IfcRelationship.
  IfcObjectDefinition is a superclass for classes that allow the instantiation and typing of physically tangible or existing objects, persons, and processes. These include, for example, the classes IfcContext (with the subclasses IfcProject and IfcProjectLibrary), IfcElement, IfcSpatialElement (with subclasses IfcSite, IfcBuilding, IfcSpace, etc.), IfcElementType, IfcStructuralActivity, IfcStructuralItem, IfcActor, IfcProcess, and IfcResource.
  IfcPropertyDefinition contains classes for grouping properties and providing templates for properties. Examples of the classes are IfcPropertySet, IfcQuantitySet, IfcPropertyTemplateDefinition, and IfcPreDefinedPropertySet. The concept of properties is described in detail in Section 3.1.9.
  IfcRelationship is the superclass for all relationship objects that are used to link classes. It describes relationships between objects, between properties, and between objects and properties. This is explained in Section 3.1.8, where examples are also given.
- The control extension declares basic classes for control objects (IfcControl and IfcPerformanceHistory, etc.) and relationship classes for assigning these classes to objects (such as IfcRelAssignsToControl). IfcControl includes classes that control or restrict the use of products, processes, and resources through rules, requests, or statements.
- The product extension is for classes of physical objects that usually have a shape and location within the project. These are, for example, elements for creating a spatial project structure and construction elements. The product information is provided as subclasses of IfcProduct for instances and as subclasses of IfcTypeProject for object types.
- The process extension expands the concept of the IfcProcess described in the IfcKernel. It contains classes for the logical mapping of processes and for task and work scheduling. The goal is to map information that is commonly used in process mapping and scheduling applications. Examples of classes in this schema are IfcTask, IfcWorkPlan, and IfcEvent. IfcTask is used for identifiable units of work, for example in the design or construction processes. An IfcWorkPlan is a work plan that can reference other work plans of the IfcWorkSchedule class, tasks of the IfcTask class, and required resources. IfcEvent is used to record actions that trigger responses or reactions, for example to identify a point in time at which information is issued.

2) ***Interoperability layer:***

This layer contains classes that can be used in different disciplines and exchanged between them. They can be referenced and specialized by all classes below them in the hierarchy, i.e., those in the domain layer.

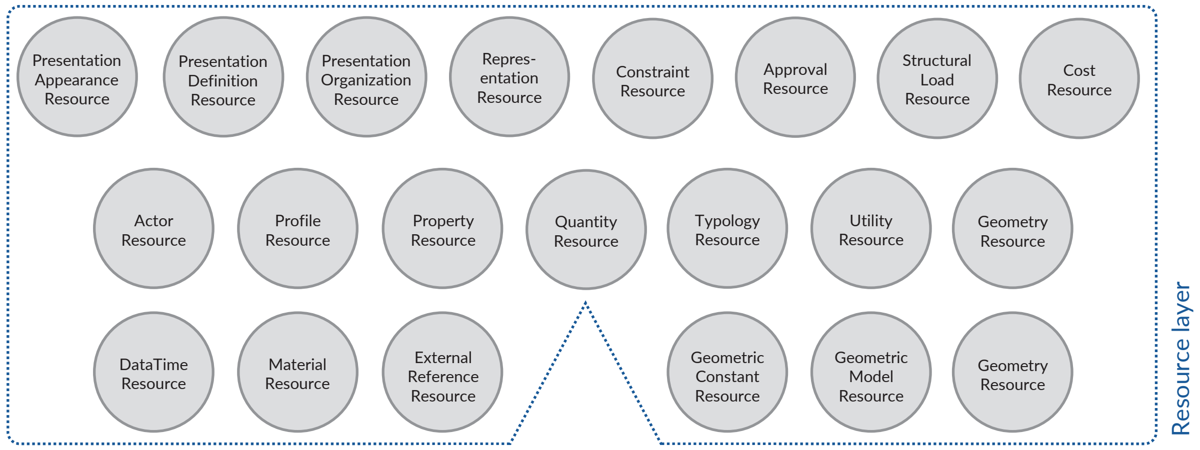
- The most important component of this layer is the Shared Building Elements schema, which contains important building element classes such as IfcWall and IfcSlab. These and other subclasses of IfcElement are used to represent the most significant functional part of a building. The classes of the Interoperability Layer are derived from classes of the Core Layer, as is the case for the classes of the Shared Building Elements schema of IfcElement.
- The Shared Building Service Elements schema defines classes for modeling flow and distribution systems and lists of features for describing building services, such as flow properties, electrical properties, and room thermal properties.
- The Shared Component Elements schema includes concepts for various small parts such as accessories and fasteners. One notable class is IfcElementComponent, which provides a representation for smaller elements that are not relevant from the perspective of the overall building structure. An example are connecting elements.
- The Shared Management Elements schema defines concepts for the management of the project. The classes of the schema are subclasses of IfcControl. The goal is to provide information classes that support the control of project scope, cost, and time.
- The Shared Facilities Elements schema defines base classes for facility management (FM), including classes for mapping furniture and other items.

3) ***Domain layer:***

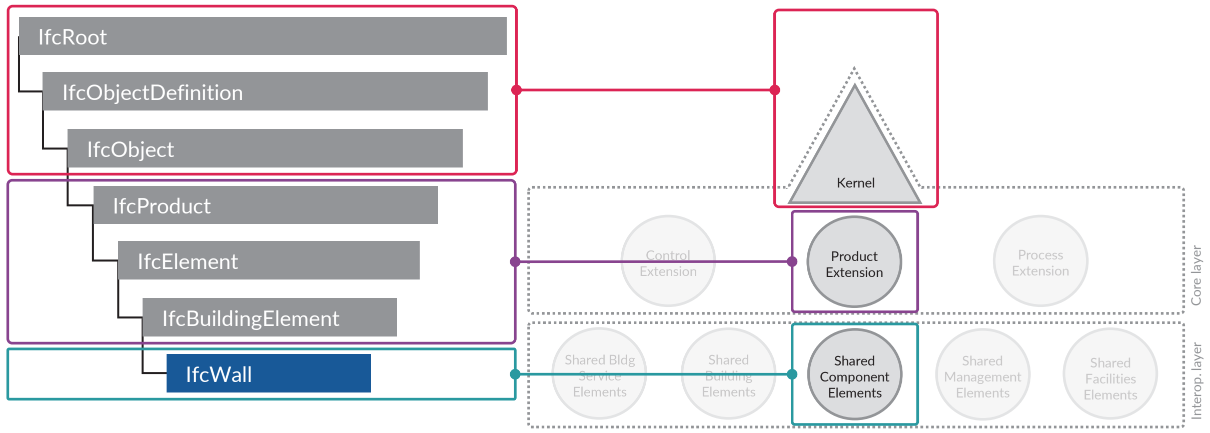
This layer organizes element classes by disciplines of construction. It contains schemas that contain specialisations of products, processes, or resources that are specific to one of eight disciplines (domains). An example of this is the Architecture Domain schema, which contains IfcDoor and IfcWindow, among others. The classes in this layer cannot be referenced or further specialized by any other layer.

4) ***Resource layer:***

This layer (see graphic), which must be considered separately, contains all schemas that include supporting resource definitions. These are not subclasses of IfcRoot (hence they are called non-rooted classes), so they have no GUID and cannot exist as standalone elements. They must therefore be referenced by at least one class of one of the other three layers. Examples of these classes are IfcMaterial, IfcCartesianPoint, IfcFacetedBrep, IfcPerson, IfcPropertySingleValue, IfcObjective and IfcRegularTimeSeries. Some essential schemas of the layer are IfcMaterialResource, IfcGeometricModelResource, and IfcDateTimeResource.



The conceptual layers of the data schema architecture are described based on a use case in the following figure. The IfcWall element class (see QR code) is part of the Shared Building Elements schema located in the interoperability layer. It is a subclass of IfcBuildingElement of the Product Extension schema of the core layer. IfcBuildingElement in turn is a subclass of IfcElement, which is a subclass of IfcProduct. Conversely, it can also be said that the superclass of IfcProduct is the class IfcObject, which belongs to the kernel, which is also in the core layer. The superclass of IfcObject is IfcObjectDefinition, whose superclass is the most abstract of all classes, IfcRoot, which is the origin of all classes that rise from the kernel.



3.1.4 Inheritance hierarchy

In programming, inheritance means that a subclass can receive (inherit) the properties of one or more superclasses. The subclasses possess additional information and represent specialisations while the superclasses are generalisations.

Attribute inheritance

In IFC, both relationships and attributes can be inherited. The implementation of relationships in IFC is discussed in Section 3.1.8. In the following paragraphs, the inheritance of attributes is explained by using the class IfcWall as an example. This class gets its available attributes from classes IfcRoot, IfcObjectDefinition, IfcObject, IfcProduct, IfcElement, IfcBuildingElement, and from IfcWall itself.

The following figure shows a section of the attribute inheritance table for IfcWall (see the QR code for IfcWall). The section shows the attributes of IfcRoot, which are inherited by all classes that originate in the kernel, i.e., all classes except those of the resource layer. IfcRoot thus forms the root of the inheritance tree of most classes. It provides the IfcGloballyUniqueId (GUID) attribute, which is necessary to uniquely identify objects. The GUID, which is automatically generated, is a 128-bit number that is compressed to a 22-digit number in order to reduce storage space for data exchange. The Owner History is another attribute of IfcRoot, which provides information about the current and past ownership and about the time of the last modification. »Name« and »Description« attributes allow a name and comment to be added (optional).

▼ Attribute inheritance

#	Attribute	Type	Cardinality	Description	G
IfcRoot					
1	GlobalId	IfcGloballyUniqueId		Assignment of a globally unique identifier within the entire software world.	X
2	OwnerHistory	IfcOwnerHistory	?	Assignment of the information about the current ownership of that object, including owning actor, application, local identification and information captured about the recent changes of the object, NOTE only the last modification in stored - either as addition, deletion or modification. IFC4 CHANGE The attribute has been changed to be OPTIONAL.	X
3	Name	IfcLabel	?	Optional name for use by the participating software systems or users. For some subtypes of IfcRoot the insertion of the Name attribute may be required. This would be enforced by a where rule.	X
4	Description	IfcText	?	Optional description, provided for exchanging informative comments.	X

3.1.5 Data structure

The IFC data structure is divided into three structural areas:

- Location structure
- Functional structure
- Material structure

First, the location structure (building site, floor, rooms with functions) is constructed in the model, then the functional structure is incorporated into the spatial structure, and lastly the material structure is added. References are used to link these three structures. An instance of a functional element carries links to the location structure (e.g., to IfcBuildingStorey) as well as to the material structure (IfcMaterial).

The consistent separation of these three structural parts is essential to provide a uniform structure, but this separation is not yet fully implemented. This can be seen, for example, in the IfcElement class, for which information about the material properties can be entered via the Pset_ConcreteElementGeneral property set, whereas this should be reserved for the classes of the schema Material Resource of the resource layer. The consistent separation is intended to ensure that materials occur only once in the structure but can be referenced as many times as necessary.

In the upcoming IFC version IFC5, the functional structure will receive a comprehensive supplement for the mapping of elements for structures in the infrastructure sector (roads, railways, bridges, tunnels). Significant additions (especially in the area of building services) for the complete mapping of building structures were already published in IFC4 in 2013. These are explained in detail in the following section.

3.1.6 Domains and element classes

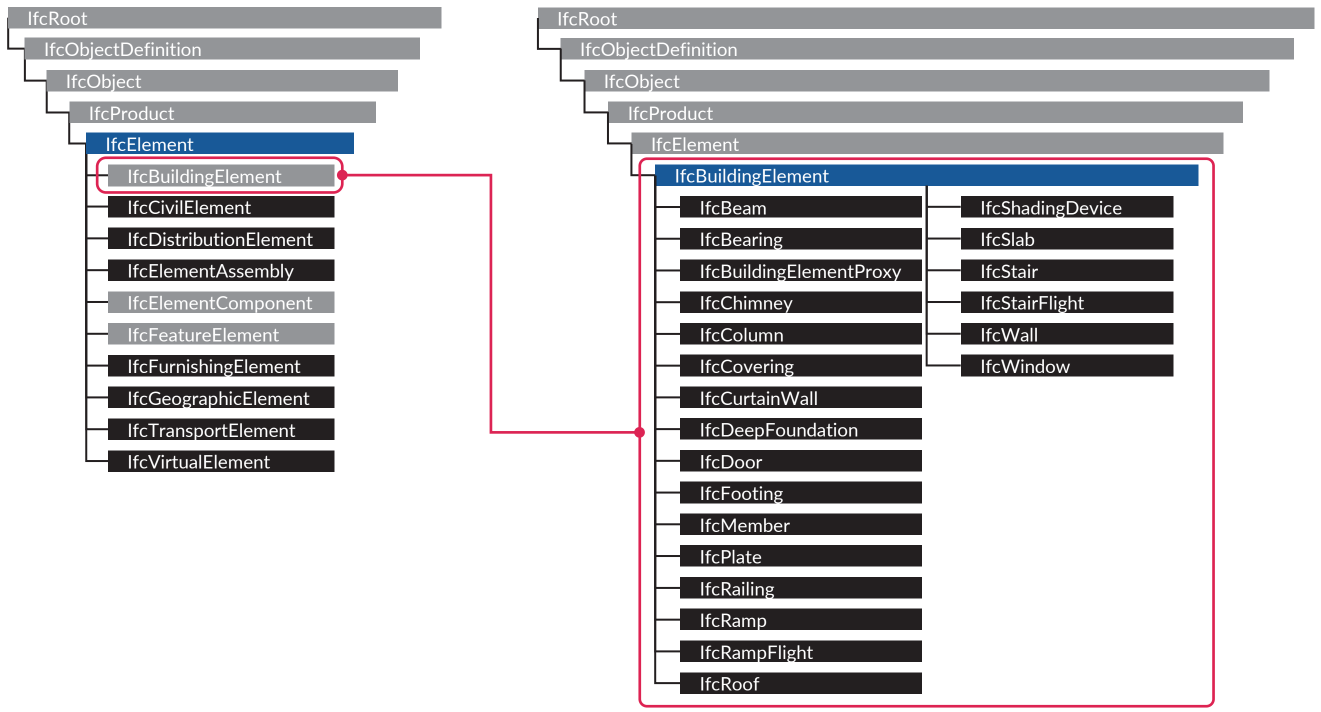
The functional element classes are used to represent buildings and are organized in domains (domain-specific data schemas) such as IfcArchitectureDomain or IfcHVACDomain (corresponding to the typical division of the planning trades). This declaration allows a clear assignment of responsibilities or filtering of model content during import or export. In addition, the shared element data schemas provide a parallel container of functional element classes that are used by several trades in parallel. An example of a functional element class is IfcSharedBldgElements, which is used to represent walls, slabs, columns and beams, among others. These are used by architects as well as for structural design.

The area of application of element classes is clearly defined. This is accompanied by a limitation of their geometric functionality (position, path, dimension), the attributes that can be derived from them (summarized in Quantity Set) as well as the characteristics that are necessary for its description (structured in PSets). In addition, the material layer set provides a specification for the assignability of materials for each element class. This can be, for example, a layer-by-layer definition for IfcWall or a differentiation between the front, filling, and back for IfcCovering. The material declaration allows the free definition of materials, to which freely defined characteristics can be added. Although the IFC specification offers detailed predefined material characteristics, these have not yet been implemented in the BIM software applications. With the introduction of DataTemplates a change in the way building data (IFC) and product information (DataTemplates) are handled is to be expected.

The element class IfcBuildingElementProxy provides an element class for any area of application for which the IFC specification used does not yet have semantics – i.e., a suitable element class – or for which the BIM software applications used do not offer any support. For example, this class is currently frequently used in transport infrastructure projects that are processed using IFC2x3, as the current BIM software applications only offer stable support for this IFC version.

3.1.7 IfcElement and its subclasses

The basic component of the so-called functional structure is the class IfcElement. IfcElement is a generalisation of all physically existing components that make up a structure. It is the superclass for a number of particularly important base classes which are necessary for the description of buildings. The following figure shows all the subclasses of IfcElement on the left side. In the context of building construction, the IfcElement subclass IfcBuildingElement is particularly relevant. In the following figure, the subclasses of IfcBuildingElement are shown on the right side, including elements such as IfcWall, IfcSlab, IfcColumn, IfcFurniture and IfcWindow.



Another subclass of IfcElement is IfcDistributionElement, which contains elements for distribution systems used in the MEP. These elements can be used for heating and cooling systems, waste water systems, and electrical systems, among others.

The IfcElement subclass IfcCivilElement, which translates into the IFC as the civil engineering element, was effectively introduced for infrastructure extensions. Currently, the class does not contain any subclasses and is merely a stub for incorporating a model for infrastructure projects that is under development. The intention is to introduce only elements that cannot be represented with elements IfcBuildingElement, IfcDistributionElement, and IfcGeographicElement of the IfcElement subclasses. These elements, which are organized horizontally, are found in the linear infrastructure assets of road, bridge, and rail construction. Horizontal organization is accomplished using the IfcSpatialZone class, in which every IfcCivilElement is contained spatially by default. The IfcSpatialZone class is a subclass of IfcSpatialElement, which is a more general spatial zone compared to the IfcSpatialElement subclass IfcSpatialStructureElement. IfcSpatialStructureElement contains mainly building-specific classes like IfcSite which are hierarchical in nature.

3.1.8 Object relations – material assignment and spatial assignment

In addition to the functional structure, i.e., essentially the elements of the class IfcElement, the spatial structure, and the material structure are fundamental components of the IFC data model. The location of the elements in the spatial structure as well as the assignment of materials to the elements is done via the object relations function.

General concept of object relations

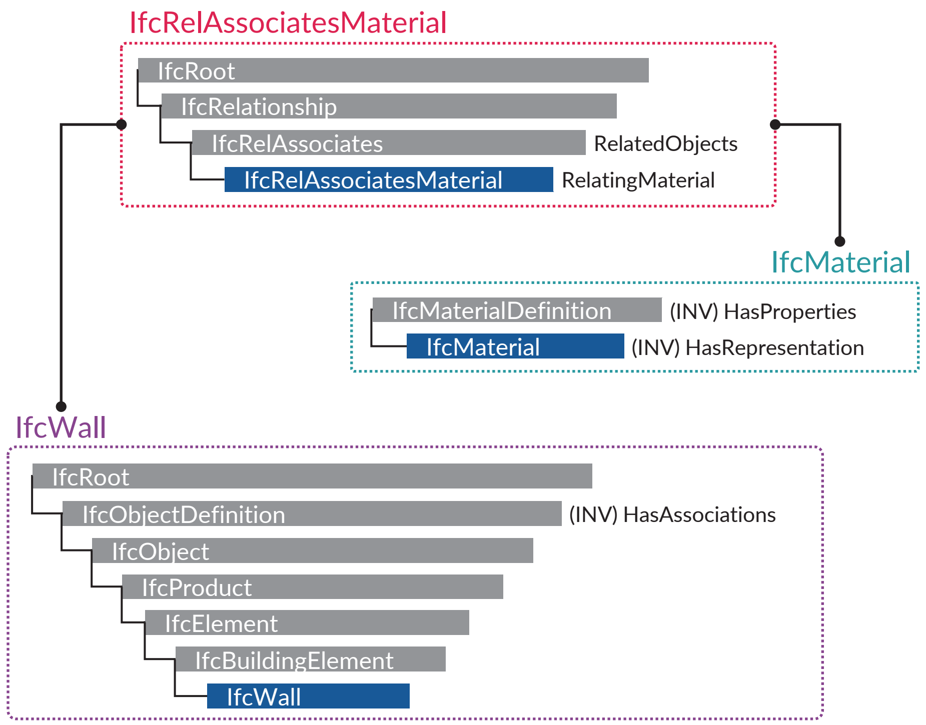
By means of the concept of object relations, components can be related to other objects. In the IFC, this is done using the principle of objectified relationships. This means that the association of two objects is established via separate, intermediate objects that represent the relationships. These relationship objects are always instances of a subclass of the IfcRelationship class, which belongs to the kernel in the core layer. The relationship objects are linked to the objects via attributes with names beginning with Related or Relating. The backward relationship is established via related inverse attributes.

Material allocation

The assignment of materials to components is an important part of every digital building model, as these are crucial for quantity determination, structural analysis, and energy demand calculations. The linking of components (i.e., subclasses of IfcElement) with materials (i.e., subclasses of IfcMaterialDefinition) is done via the relationship class IfcRelAssociatesMaterial. The superclass of this relationship class is IfcRelAssociates, the various subclasses of which establish relationships with different information external or internal to the project (material information in the case of IfcRelAssociatesMaterial, for example).

For the relationship class IfcRelAssociatesMaterial, the following image illustrates an example of a possible relationship. IfcRelAssociatesMaterial has the attribute IfcRelatingMaterial and inherited from IfcRelAssociates also the attribute IfcRelatedObject. The former attribute references subclasses of IfcMaterialDefinition, such as IfcMaterial or even IfcMaterialLayerSet which is required for composite materials. The second attribute refers to subclasses of IfcObjectDefinition, such as IfcWall. The class IfcWall has the inverse attribute HasAssociations due to attribute inheritance. The linking achieved by means of the attributes is shown in the graphic.

Materials can be named using the Name attribute. In addition, subclasses of IfcMaterialDefinition can be assigned further material properties, such as mechanical, thermal, or optical properties, via the inverse attribute HasProperties. Furthermore, the class IfcMaterial can be associated with representation information, such as hatchings in the 2D representation or information for renderings, via the inverse attribute HasRepresentation.

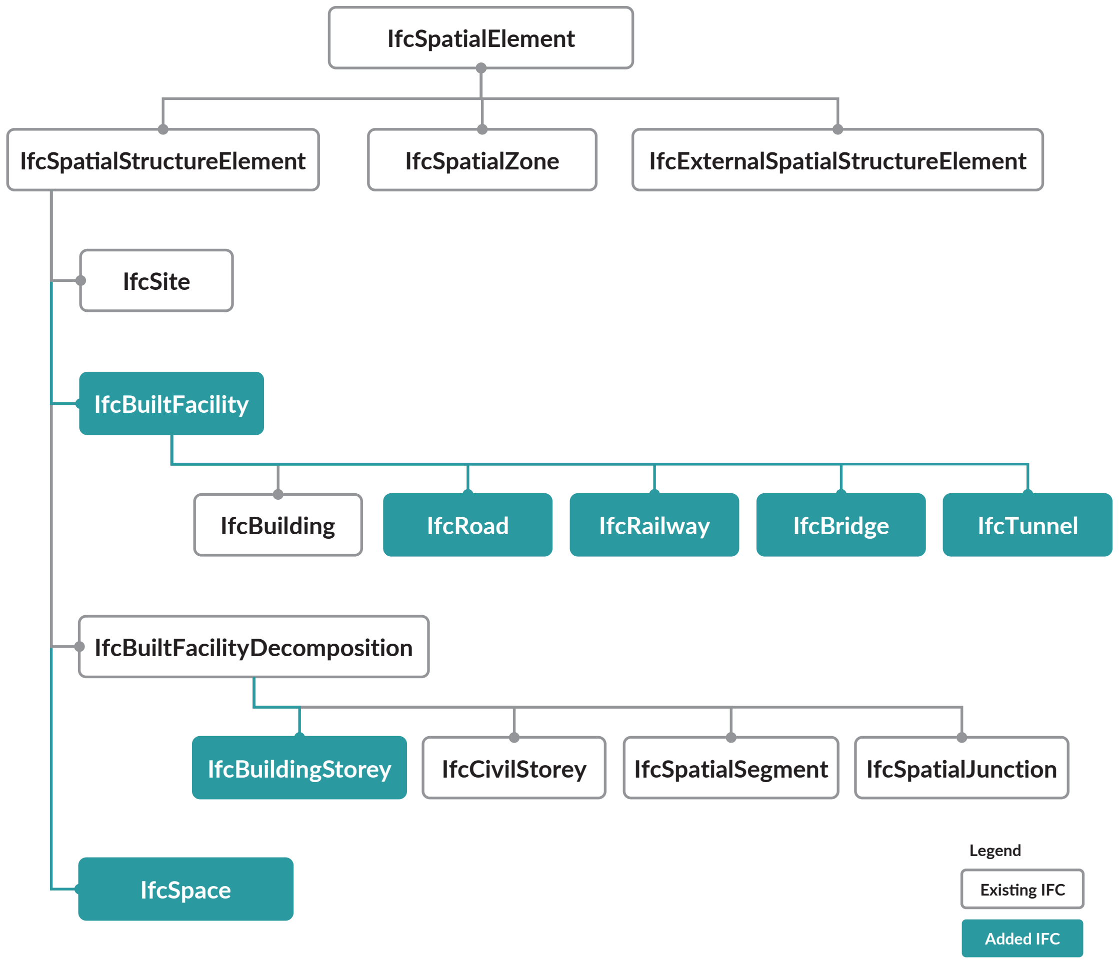


Spatial allocation, location structure

The spatial structuring of the components is fundamental for every building model. When creating a project, the so-called location structure is created first. Subsequently, the components are logically embedded in it.

The scope of the location structure was expanded considerably in IFC4.1. While previously it was possible only to describe structures in the area of building construction (even though it was sometimes also used for infrastructure projects), IFC4.1 contains a complete infrastructure addition. The following graphic shows this modification. The noncolored structural components are existing building construction components while the turquoise components are the new infrastructure components.

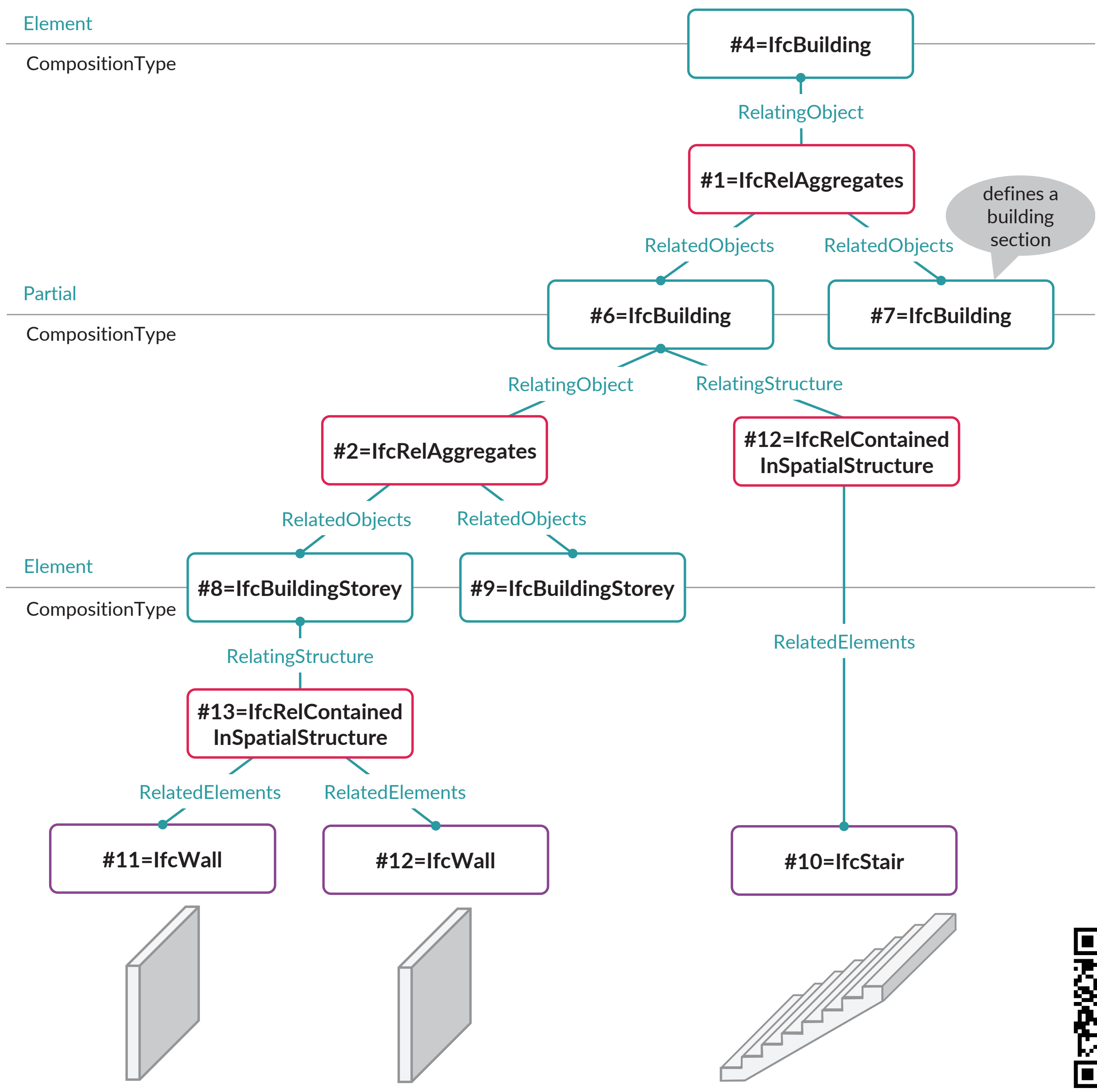
Initially, the additions were made at the IfcBuilding level – this has now been reorganized by IfcBuiltFacility into a group of different building types (IfcRoad, IfcRailway, IfcBridge, IfcTunnel). In addition, changes were made at the IfcBuildingStorey level. IfcBuiltFacilityDecomposition now also allows IfcBuildingStorey and IfcCivilStorey to be used to structure civil engineering structures, and IfcSpatialSegment and IfcSpatialJunction to provide corresponding options to map linear structures. The latter two structural components in particular have a significant impact on the applicability of IFC in the infrastructure sector, and comprehensive support for the mapping of route alignments has been implemented in the so-called »IFC alignment«.



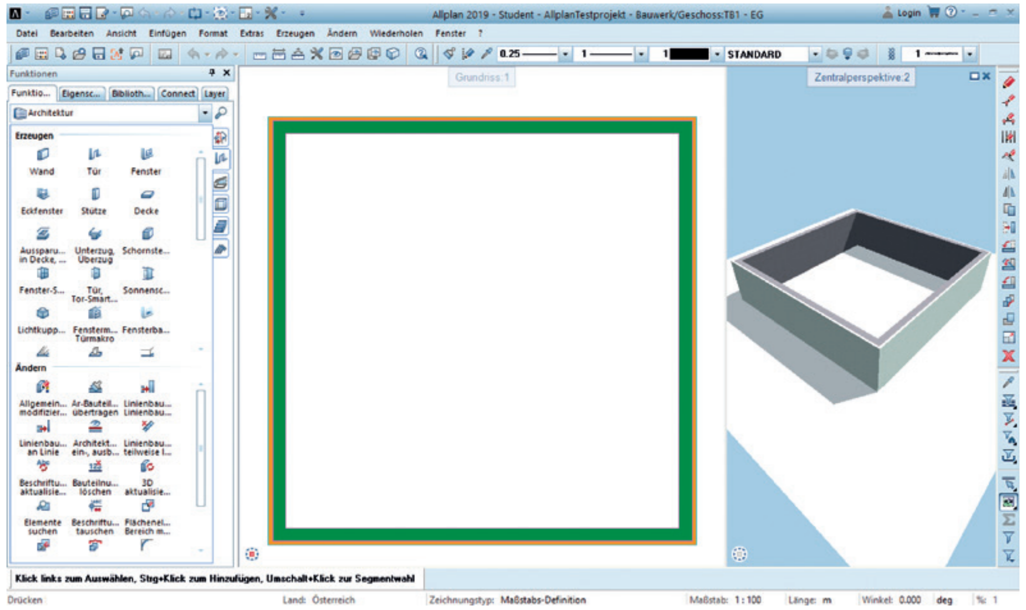
In IFC, the location structure consists of spatial objects. In the case of a building, the room objects are instances of subclasses of IfcSpatialStructureElement. These include the classes IfcSite, IfcBuilding, and IfcBuildingStorey (i.e., building site, building, and story). They are linked to a hierarchical project structure via relationship objects of the IfcRelAggregates class. An example of the linking of such room objects using IfcRelAggregates is shown below. The IfcRelAggregates relationship class, which is a subclass of IfcRelDecomposes, is used to link IfcObjectDefinition subclasses. In this particular case, it is used to organize several spatial objects into a spatial group.

The relationship class IfcRelContainedInSpatialStructure is used to assign components to the spatial objects. Two instances of this are also shown in the following image. This class is a subclass of IfcRelConnects (see image in »More subclasses of IfcRelationship«). It is worth noting that each component can only be assigned to one spatial object. However, if a component, such as a cross-story façade element, is associated with multiple spatial objects, this additional assignment can be made using the IfcRelReferencedInSpatialStructure relationship class. The linking of components to the relationship object is done using the inverse ContainedInStructure attribute of the IfcElement class. Consequently, elements of all subclasses of IfcElement can be linked to room objects. In the

example shown, an instance of the IfcStair class is linked to a room object of the IfcBuilding class, and two objects of the IfcWall class are linked to a room object of the IfcBuildingStorey class.



In the following paragraphs, the mapping of relationships in an IFC file is illustrated with another example. For this purpose, four walls were modeled using Allplan 2019-1, each consisting of a reinforced concrete layer and a thermal insulation layer:



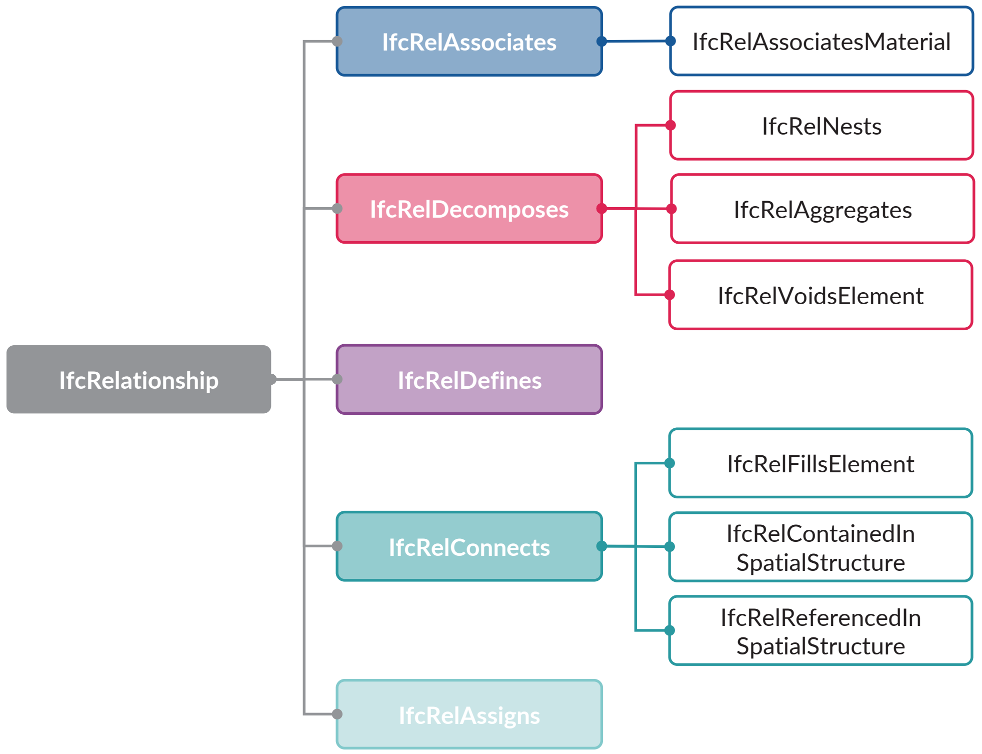
The following image shows the IFC file exported from Allplan, opened in Microsoft Excel. Almost 90% of the rows of the DATA section are hidden and the remaining rows are highlighted for better clarity. Any information related to the properties of the walls and the materials assigned to them are hidden. The display thus contains only information about the spatial structure and the geometry of the objects and how they are linked to each other.

Instances colored yellow are related to the project structure and the room objects, those colored blue to the walls and their geometry. Instances colored gray are referenced across the board. The bottom two orange lines contain two instances of the IfcRelAggregates class. The first instance locates the object with IFC file internal identifier #38 (the building of class IfcBuilding) in the project with ID #26. The second locates the floor of class IfcBuildingStorey (ID #54) in the building. The pink line above these two lines shows an instance of the IfcRelContainedInSpatialStructure class. It locates the four walls of class IfcWallStandardCase (with the identifiers #198, #386, #546, and #710) in the floor with ID #54. Since no rooms were modeled in the project and adjacent walls are not connected by relationship objects in IFC, their relative placement to each other can only be understood via their coordinates.


```
#11= IFCOWNERHISTORY(#7,#10,$,.NOTDEFINED.,$,$,$,1581848416);
#26= IFCPROJECT('3xUAvmkUzENPEaZ0_s0awJ',#11,'AllplanTestprojekt',$,$,$,$,(#65),#36);
#36= IFCUNITASSIGNMENT((#13,#14,#15,#19));
#38= IFCBUILDING('0wVmWt28TDpvgEtBzNOUSA',#11,'Default Building',$,$,#50,$,$,.ELEMENT.,$,$,$);
#47= IFCAXIS2PLACEMENT3D(#48,$,$);
#48= IFCCARTESIANPOINT((0.,0.,0.));
#50= IFCLOCALPLACEMENT($,#47);
#54= IFCBUILDINGSTOREY('2au4f2cLb9SQe_neNqe1FT',#11,'Geschoss',$,$,#58,$,$,.ELEMENT.,0.);
#55= IFCAXIS2PLACEMENT3D(#56,$,$);
#56= IFCCARTESIANPOINT((0.,0.,0.));
#58= IFCLOCALPLACEMENT(#50,#55);
#65= IFCGEOMETRICREPRESENTATIONCONTEXT($,'Model',3,1.000000000000000E-5,#21,$);
#68= IFCAXIS2PLACEMENT3D(#69,#71,#73);
#69= IFCCARTESIANPOINT((11013.29361463148,18449.9287310378,-200.));
#71= IFCDIRECTION((0.,0.,1.));
#73= IFCDIRECTION((-1.,0.,0.));
#75= IFCLOCALPLACEMENT(#58,#68);
#77= IFCPRODUCTDEFINITIONSHAPE($,$,(#126,#141));
#81= IFCARBITRARYCLOSEDPROFILEDEF(.AREA.,'',#84);
#84= IFCPOLYLINE((#86,#88,#90,#92,#94,#96,#98,#100,#86));
#86= IFCCARTESIANPOINT((-10000.,-400.));
#88= IFCCARTESIANPOINT((0.,-400.));
#90= IFCCARTESIANPOINT((0.,-300.));
#92= IFCCARTESIANPOINT((-100.,-300.));
#94= IFCCARTESIANPOINT((-100.,-0.));
#96= IFCCARTESIANPOINT((-9900.,-0.));
#98= IFCCARTESIANPOINT((-9900.,-300.));
#100= IFCCARTESIANPOINT((-10000.,-300.));
#102= IFCCARTESIANPOINT((-10000.,-400.));
#104= IFCEXTRUDEDAREASOLID(#81,#105,#112,2500.);
#105= IFCAXIS2PLACEMENT3D(#106,#108,#110);
#106= IFCCARTESIANPOINT((10000.,400.,0.));
#108= IFCDIRECTION((0.,0.,1.));
#110= IFCDIRECTION((1.,0.,0.));
#112= IFCDIRECTION((0.,0.,1.));
#126= IFCSHAPEREPRESENTATION(#61,'Body','SweptSolid',(#104));
#133= IFCPRESENTATIONLAYERWITHSTYLE ('Daemmung',$,(#104,#323,#483,#647),'MW_DAEMMUN',.T.,.U.,.F.,(#134));
#141= IFCSHAPEREPRESENTATION(#143,'Axis','Curve2D',(#145));
#143= IFCGEOMETRICREPRESENTATIONSUBCONTEXT('Axis','Model',*,*,*,*,#65,$,.MODEL_VIEW.,$);
#145= IFCPOLYLINE((#147,#149));
#147= IFCCARTESIANPOINT((0.,0.));
#149= IFCCARTESIANPOINT((10000.,0.));
#198= IFCWALLSTANDARDCASE('0MnkgC4Fv5kfTsvYU2Myo8',#11,' ',$,$,#75,#77,$,$);
#386= IFCWALLSTANDARDCASE('3QrME8v0LDvhhz5vzIpgYG',#11,' ',$,$,#299,#300,$,$);
#546= IFCWALLSTANDARDCASE('1lisxhtQb1$h2z4CM719Kf',#11,' ',$,$,#459,#460,$,$);
#710= IFCWALLSTANDARDCASE('1e7$owAd98_v64KEXwR6Pd',#11,' ',$,$,#623,#624,$,$);
#780= IFCRELCONTAINEDINSPATIALSTRUCTURE('0UVDK$JnLCkuGl5p_d2wxo',#11,$,$,(#198,#386,#546,#710),#54);
#787= IFCRELAGGREGATES('21HSISdH98seVOROFZ51BE',#11,$,$,#26,(#38));
#791= IFCRELAGGREGATES('2MWo5JTgv4HOO2$ZGD4AfV',#11,$,$,#38,(#54));
```

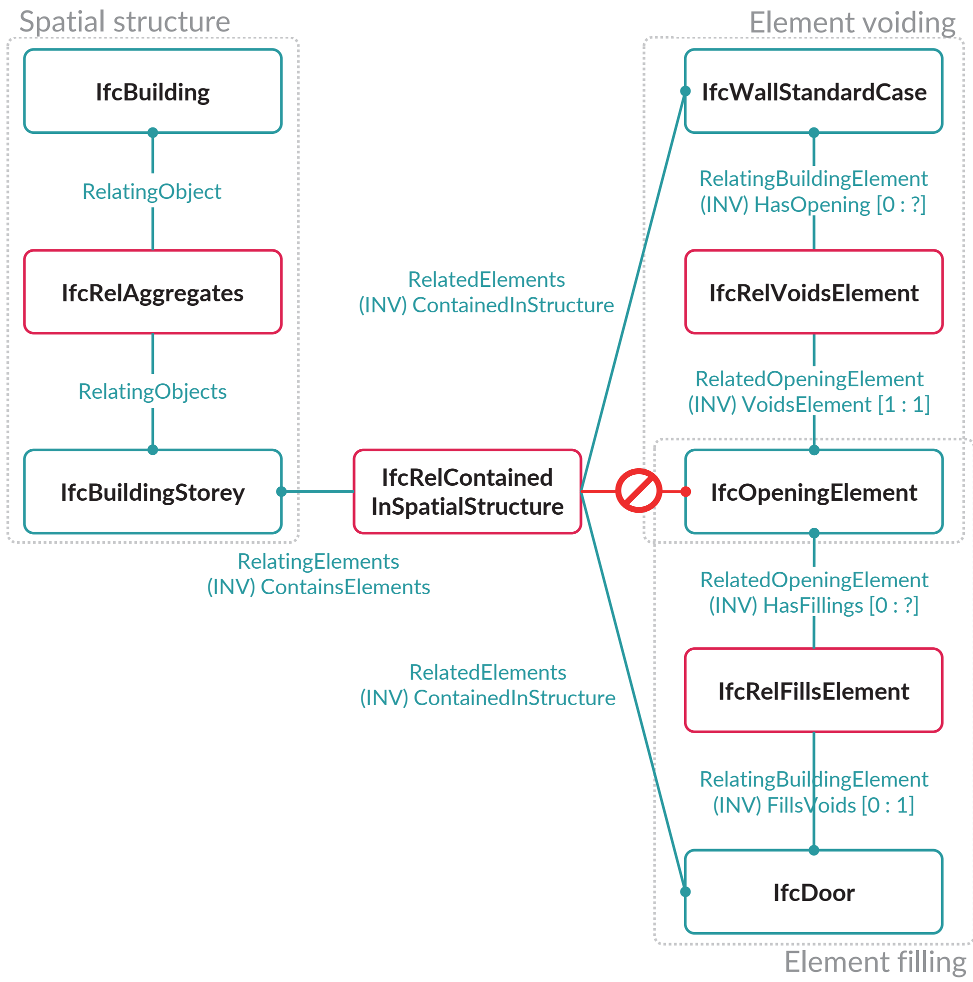
Other subclasses of IfcRelationship

The five direct subclasses of IfcRelationship and some of their subclasses are shown in the following image:



IfcRelAssociates associates information sources for materials, documents, and restrictions located inside or outside the project data with objects of the classes IfcObject and IfcTypeObject, and in certain cases of the class IfcPropertyDefinition. Details about the IfcRelAssociates subclass IfcRelAssociatesMaterial can be found above in the section titled »Material assignment«.

In IFC, IfcRelDecomposes is interpreted as a »part-to-whole relationship«. It defines the general concept of composite or decomposed elements. This relationship class can be used to formulate a part-to-whole hierarchy, with the ability to navigate from the whole (composition) to a part and vice versa. There are several types of decompositions, for example class IfcRelNests, which can be used to link cost elements where one forms a container (»nest«) for the others, and class IfcRelAggregates, which can be used to form a representation of a frame construction as a grouping (aggregation) of a beam and a column. This class is also used for linking spatial objects (see »Spatial allocation, location structure« above). Furthermore, class IfcRelVoidsElement provides the possibility to model an opening in an element. An instance of this class representing an opening in a wall can be found in the following image:



IfcRelDefines contains subclasses for mapping object types to object instances (see Section 3.1.10), for mapping property sets to object instances (see Section 3.1.9), and for mapping property set templates to property sets.

IfcRelConnects contains classes that create connections between objects under special conditions. For subclass IfcRelContainedInSpatialStructure (see »Spatial allocation, location structure« above), the condition is that an object can be assigned only to a single spatial structure element. IfcRelReferencedInSpatialStructure is used to assign an object to another spatial structure element. The IfcRelFillsElement class allows a one-to-one relationship between an opening and an element that fills it, such as a door in a wall opening. This example is illustrated in the previous image. The opening itself is linked only to the elements, i.e., the door and the wall in the example, and not to the spatial object in which it is located.

IfcRelAssigns is the superclass for various »link« relationships that can be used between instances of IfcObject and their direct subclasses. A »link« refers to the association where the object »Customer« (client) applies the services of the other object (»Supplier«). The following graphic shows an example where an instance of the IfcResource subclass IfcLaborResource is assigned as a supplier to an instance of the IfcProcess subclass IfcTask as a client. The relationship object for this link is the IfcRelAssigns subclass IfcRelAssignsToProcess.

3.1.9 Properties

In order to implement an extension or specialisation of classes in IFC without creating new subclasses, it is possible to define properties of objects. In IFC, the properties are implemented in two ways: by attributes or properties (characteristics). This dichotomy was provided for in IFC because properties required by users are not always internationally standardized and predictable. However, the schema should not be inflated any further. Attributes are used to store basic properties of objects directly in the schema. An example of this is the attribute OverallHeight of the class IfcDoor, which can be specified when instantiating a door object. Attributes are static and thus cannot be generated by users. The dynamically generated properties have opposing characteristics. They offer the possibility of national or user-specific extensions to the IFC schema.

Properties can be defined freely using the subclasses of IfcProperty, from the Property Resource schema of the Resource Layer. They are defined using a tuple of the form »name-value-datatype-entity«. The most commonly used subclass of IfcProperty is IfcPropertySingleValue, where exactly one value can be specified. The template for properties of the IfcPropertySingleValue class is »Name-NominalValue-Type-Unit«. For example, property IfcLoadBearing of class IfcWall is defined with the tuple »Name: Load Bearing; Value: YES; Data type: Boolean«. Another subclass of IfcProperty is IfcPropertyEnumeratedValue, where a value can be selected from predefined options which are referenced via the EnumerationValues attribute. Using the subclass IfcPropertyBoundedValue, the attributes UpperBoundValue and LowerBoundValue can be defined.

Individual properties are grouped in property sets (property lists). These property sets (Pset) are arranged thematically. Each element class includes at least one standard Pset, which is typically designated with the suffix Common, e.g., Pset_CoveringCommon. Some Psets (e.g., Pset_Warranty) are assigned to several element classes at the same time. For some years now, it has been the custom for individually created Psets to be designated with the suffix Specific, e.g., Pset_CoveringSpecific.

The class IfcPropertySet has the attribute HasProperties, which establishes the link to the class IfcProperty. This provides a kind of »metamodel« that can be further declared by populating the name attribute of the property set and the attributes of the associated properties.

The superclass of IfcPropertySet is the class IfcPropertySetDefinition; this is a part of the IfcKernel in the core layer. Apart from the dynamically extendable property lists of the IfcPropertySet class, it also defines statically defined property lists of the IfcPreDefinedPropertySet class. The few predefined property lists contain only attributes for architectural elements, such as the IfcDoorLiningProperties list, which can be assigned to the IfcDoor element and contains specialisations for door frames.

A property set is linked to an object via the IfcRelDefinesProperties relationship object (see Section 3.1.8). Property sets are linked to the relationship object via the DefinesOccurrence attribute of the IfcPreDefinedPropertySet class. The attribute IsDefinedBy allows all subclasses of IfcObject to be linked to the relationship object. An assignment to an object type of class IfcTypeObject (see Section 3.1.10) is also possible and can be done directly via the attributes DefinesType or HasPropertySets.

In the database of the bSDD they are managed in the form of XML files with the naming scheme »Pset_.xml«.

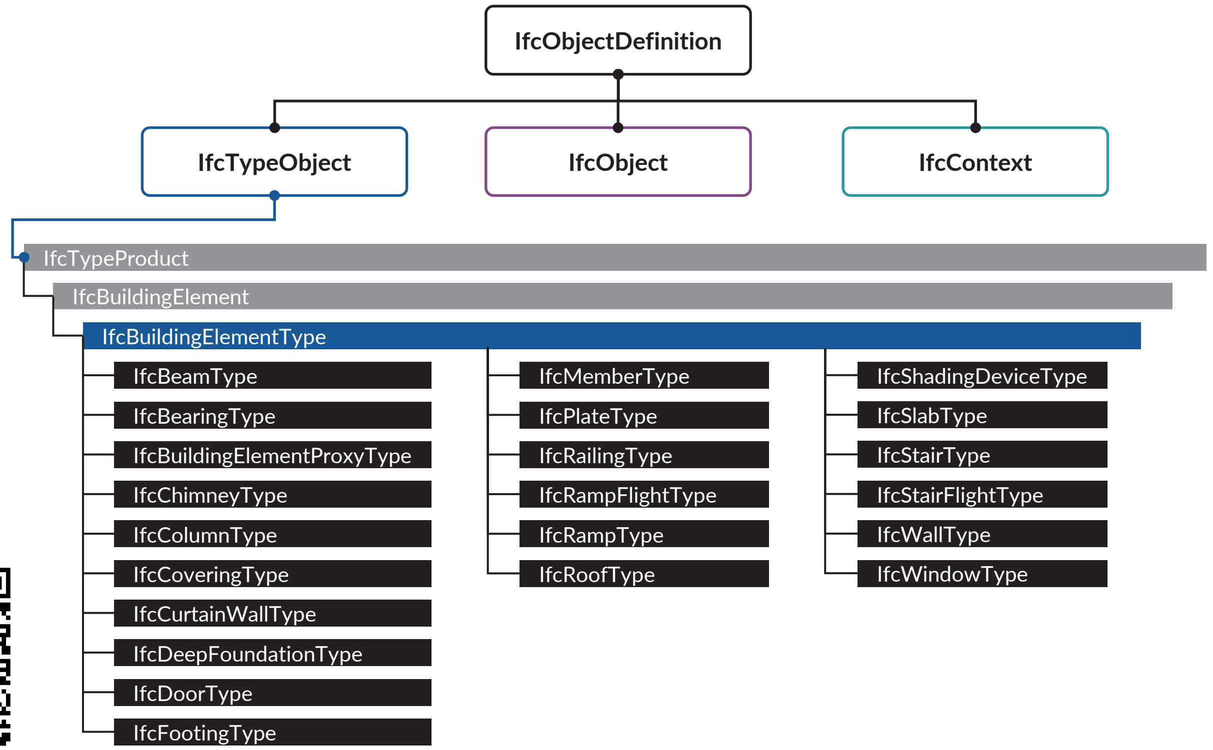
Units

The declaration of IfcValue (for example IfcVolumeMeasure) can be used to precisely control the characteristics regarding the content, units, or value ranges to be used. Besides the measurement unit, the specification is usually also defined, e.g., the restriction to real numbers. With the attribute ValueTypes, the IFC specification includes a comprehensive definition of all existing SI units (see QR code).

3.1.10 Object types

In IFC, the concept of object types is provided to efficiently describe repeatedly used components. To do so, a reusable pattern, a kind of template, is predefined. The object types can define attributes and properties, which are then passed on automatically to the linked objects. This is referred to as pre-instantiation. When the object types are instantiated, only data, such as spatial location or relationships to other objects, is specified. This data cannot be specified via object types.

All object types are subclasses of IfcTypeObject, whose superclass is IfcObjectDefinition, which is also the superclass of IfcObject. For most objects there are corresponding object types available, which have the same name as the object but are suffixed with »Type«, e.g., IfcDoorType to the object IfcDoor. The subclasses of the IfcTypeObject subclass IfcBuildingElementType are shown in the following figure:



For a covering (IfcCovering), there could be the following type declarations: Ceiling, Flooring, and Insulation. Some element classes such as IfcWindow, IfcDoor and even IfcPile have multiple type declarations. The type declarations for IfcPile include, for example

- *PredefinedType* with the enumerations (**IfcPileTypeEnum**) BORED, DRIVEN, JETGROUTING etc., and
- *ConstructionType* with the enumerations (**IfcPileConstructionEnum**) CAST_IN_PLACE, COMPOSITE, PRECAST_CONCRETE, etc.

Such a concept will probably also be used in other element classes in the future, since the separation of the characteristics and the structure into two separate types allows for much cleaner declarations overall.

IFC4.3 introduces so-called multityping, which allows the simultaneous multiple declaration of types. Until IFC4.2, only the unambiguous declaration of types was possible.

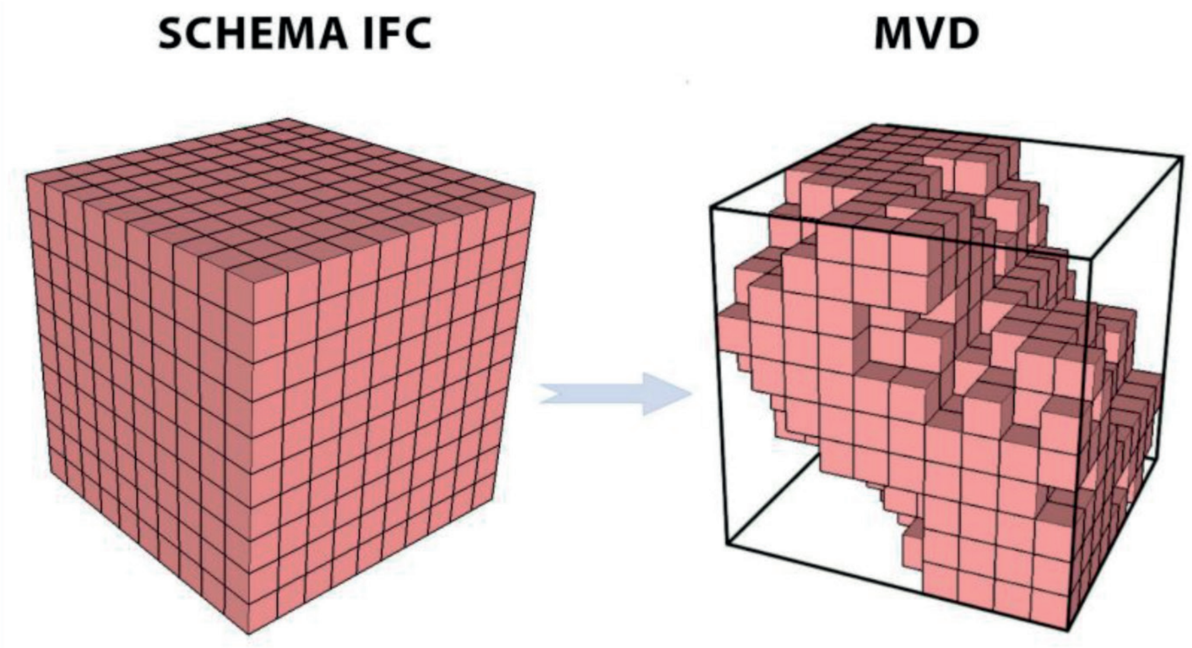
3.2 Model view definition (MVD)

The model view definition (MVD) is an essential basis for describing transfer requirements as well as their technical implementation. The implementation and certification of IFC in BIM software applications is based on MVDs.

3.2.1 Benefit of MVDs

An MVD is created in the context of a transfer requirement, e.g., for the coordination of different domain models. It defines a subset of the IFC specification (IFC schema). This subset focuses on the requirements (exchange requirements) of both the creator and the recipient of the information. The requirements are elicited on the basis of an IDM (information delivery manual) in accordance with ISO 29481. The delimitation of the IFC specification by means of an MVD can affect the following content:

- element classes and types and
- quantity sets, Psets, and characteristics.



The integration of the infrastructure requirements into the IFC specification causes an increase in the required element classes. It is becoming increasingly difficult to implement the entire IFC specification in BIM software applications, which is why it is useful to have the restrictions of an MVD. MVDs allow the functional scope of BIM software application to be tailored to the requirements relevant to the MVD. Therefore, the certification process (see QR code) of buildingSMART for BIM software applications is based on MVDs. MVDs have a harmonizing or consolidating effect on the software market, as they represent a kind of template for the required scope of functions in information creation, transfer, and interpretation.

3.2.2 Established MVDs and their objectives

Coordination View 2.0 (CV 2.0) was the first MVD to establish itself on the market of BIM software applications. It was developed in the context of IFC2x3 TC1 (2.3.0.1). The scope of CV 2.0 is the provision of domain models (architecture, structural design, building services engineering) for the overall coordination of building construction projects during the planning phase.

The geometric transfer options are not overly restricted and allow flexible adaptation. Model content can be transferred both with extruded geometry and with precise geometry (BREP – boundary representation). Transfer with extruded geometry allows the best possible native reuse in the target application. In contrast, transfer with precise geometry (BREP) allows exact geometry reproduction in the target application. In BREP mode, components can be broken down into their constituent parts (e.g., wall layers) and output as individual parts (components). In this way, the layer-by-layer evaluation/analysis of a model is possible. In IFC2x3, complex geometries are triangulated to be transferred.

CV 2.0 has been certified for many BIM software applications on the market and is currently the most widely used MVD. Due to a lack of alternatives, it is sometimes also used for transport infrastructure projects on an interim basis, with IfcBuildingElementProxy being improvised due to infrastructure element classes not yet being available or implemented in advance in the BIM software application. The fact that the location structure (SpatialStructure) has been developed mainly for above-ground construction (neglecting, e.g., infrastructure) and the imprecise handling of the coordinate system of the BIM software applications (in interaction with IFC) are frequently encountered problems.

Reference View 1.2 (RV 1.2) is the second established MVD. It was developed in the context of IFC4 ADD2 TC1 (4.0.2.1). RV 1.2 focuses on the provision of domain models as a reference (architecture, structural design, building services engineering) for the overall coordination of building construction projects during the planning phase.

In contrast to CV 2.0 the geometric transfer options are limited and geared toward the use case of model coordination. The model content is transferred with precise geometry (BREP – boundary representation). This allows for an exact geometry reproduction in the target software application. In BREP mode, components can be broken down into their constituent parts (e.g., wall layers) and output as individual parts (components). In this way, the layer-by-layer evaluation/analysis of a model is possible. IFC4 ADD2 TC1 (4.0.2.1) now also offers geometry description using NURBS for BREP, which is much more precise and space-saving (data volume) than the triangulation methods of IFC2x3.

As of December 2020, RV 1.2 has been certified for six BIM software applications on the market – but only for IFC export. Due to a lack of alternatives, it is sometimes also used for transport infrastructure projects on an interim basis, with IfcBuildingElementProxy being improvised due to infrastructure element classes not yet being available or implemented in advance in the BIM software application. The fact that the location structure (SpatialStructure) has been developed

mainly for above-ground construction (neglecting, e.g., infrastructure) often poses a problem. The certification of RV 1.2 is less tolerant to errors; therefore, the execution of RV 1.2 certifications takes more time than those of CV 2.0 certifications. However, it can be assumed that RV 1.2 certifications provide a much more homogeneous implementation quality for the BIM software applications.

3.2.3 Future MVDs and their objectives

Since RV 1.2 implements the use case of model coordination in a much more focused manner than CV 2.0, at least one more MVD for IFC4 is required that supports the use case of model transfer (interoperability). This is necessary, for example, for the provision of the architectural model to the structural engineer so that she/he can build a structural model. This MVD is also required for the transfer of the model to the client at the end of the project so that the client can subsequently update the model with any changes made to the structure.

The Design Transfer View 1.1 (DTV 1.1) was developed for exactly this purpose in the context of IFC4 ADD2 TC1 (4.0.2.1). DTV 1.1 focuses on the transfer of domain models between two BIM software applications – but only in one direction and not in an interplay (round trip). In contrast to CV 2.0, the geometric transfer options are thereby restricted and focused on the use case of model transfer. The model content is transferred with extruded geometry. This allows for native use in the target software application. As of December 2020, DTV 1.1 is not yet certified for BIM software applications.

Quantity View 0.1 (QV 0.1) is an MVD that focuses on the use case of model-based mass and cost determination. It is currently under development (draft status) and not yet certified for BIM software applications (as of December 2020).
Basic FM Handover View (FM) is an MVD that focuses on the use case of data transfer of model information to FM (facility management) at project completion (see QR code). It was created in the context of IFC2x3 TC1 (2.3.0.1). The status of FM is »official«, but is not yet established on the market and not yet certified for BIM applications (as of December 2020).

3.3 BCF comments

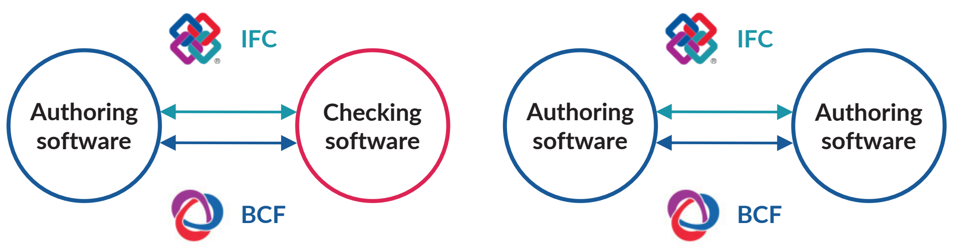
BCFs identify questions and problems regarding dedicated model elements and serve to communicate the deficiencies between the BIM organizational units. In the interaction between the ISO and buildingSMART standards, the BCF assumes the role of data interface for communication without transporting actual model elements.

BCF (or BCF comments) always contain

- the GUID (globally unique identifier),
- the assigned name,
- stored viewpoint(s) with camera position on selected model elements, and visibilities and colorings of model elements (IFC coordinates),
- images (in relation to viewpoints),
- annotations in 3D space,
- description, date, author, addressee, group assignment (e.g., discipline or BIM organizational unit),
- comments (author, date, viewpoint),
- attached files, and
- the status (e.g., open, closed).

As a standardized XML file (file extension ».bcf« or ».bcfzip«), a BCF does not contain the model or parts of it but establishes a reference relationship to model elements via their GUID. The GUID is an automatically generated number with 128 bits; it is unique and cannot be changed.

Their simple format allows software manufacturers to easily integrate the functionality into the relevant software applications. BCFs are used by all BIM organizational units. Their main scope is in the area of quality assurance of model management, since they communicate and document problems at the same time. However, BCFs are also used in small coordination cases between BIM specialist/technical coordination (BFK) and BIM designer (BIM Ersteller BE) in order to be able to coordinate questions about model and planning content:



In addition, the BCF can have different uses in the various performance phases.

In the design phase:

- quality assurance/quality control (QA/QC) documentation,
- identification of design coordination problems (collision detection) between domain models and
- comments on design options, object alternatives, and materials.

In the tender and award phase:

- coordination of the tender and clarifications and
- cost and supplier information for objects, assemblies, and/or systems.

In the construction phase:

- quality assurance/quality control (QA/QC) of installation records,
- tracking the availability of items/materials and coordinating substitute products, and
- collection of last-minute information for the transfer to owner/operator.

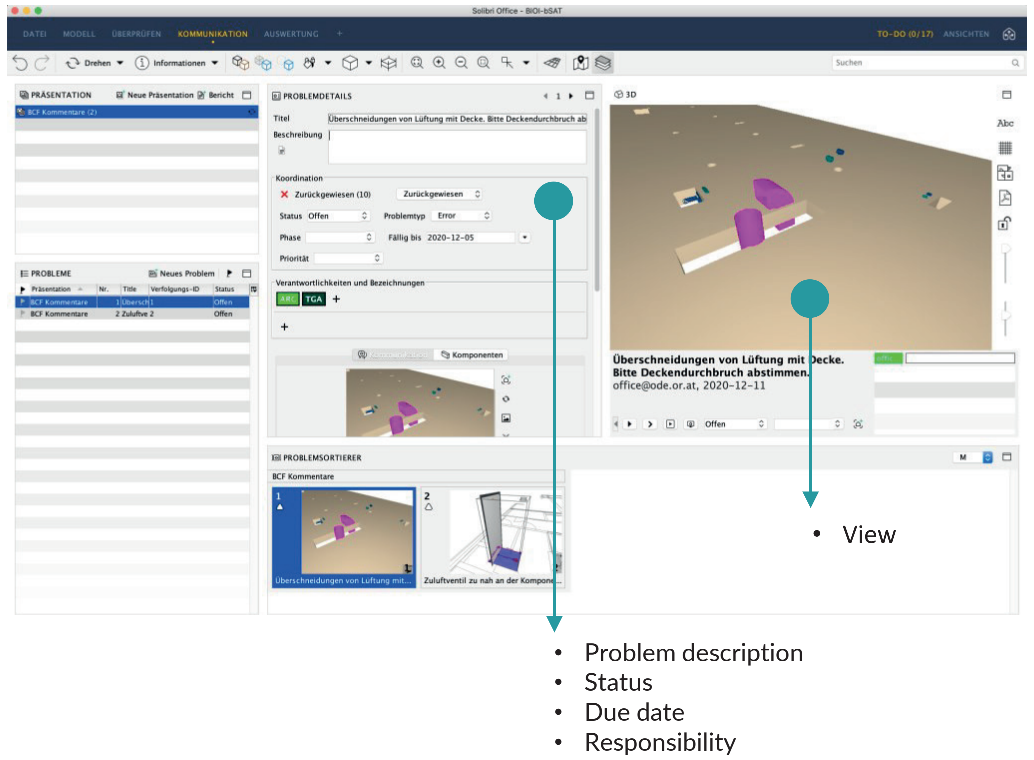
In the operating phase:

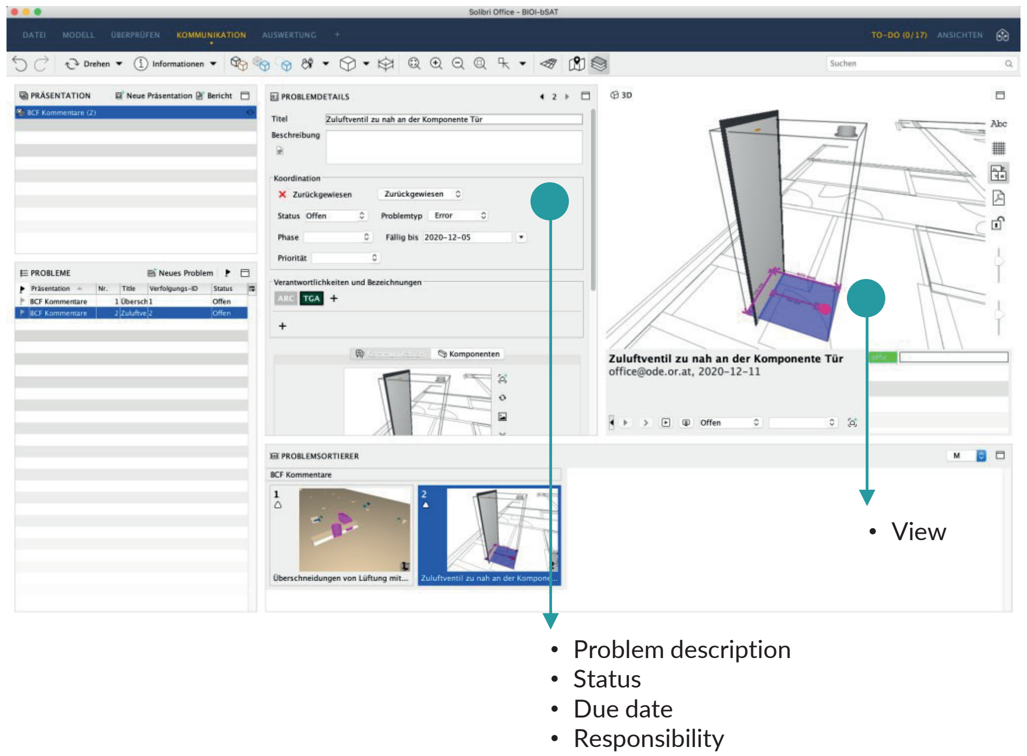
- notes on handover models in the event of changes to the plant and its many elements during operational use, and
- owner's notes on improvements needed.

The comments in BCFs should always be precise, brief, and value-neutral. The selected views of the model content should always be clearly displayed (by visibilities and colorings). The status of BCFs should always be kept up to date. When included problems have been solved, the status should be set to »closed«. These guidelines facilitate a good workflow between all project participants and ensure that the BCF functionality can also be used effectively in other software applications.

In the interests of transparency and consistency, BCFs should always be exchanged via a defined platform, regardless of when and how they are used. This can be the CDE of the respective project or an additional web-based collaborative platform intended for this purpose. A good platform also provides a good overview of the status of a project via its functionalities and representations – this can be mapped via the BCFs. By assigning them to groups (BIM organizational units and domain models), to responsibilities in the issues and to the status of all BCFs, it is not only possible to identify individual critical points but also to map critical project performance in good time.

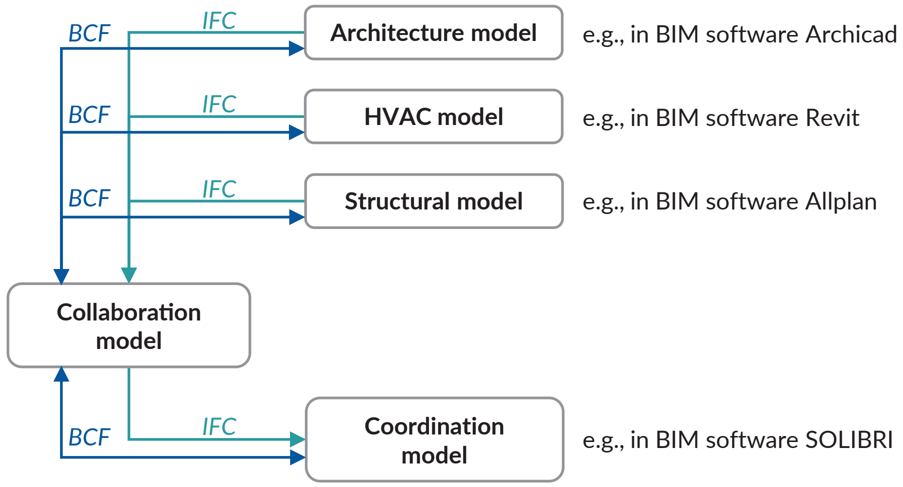
The following images show typical BCF comments. The problem description, the status, the due date as well as the responsibility are located in the central area. Shown on the right are the corresponding views (viewpoint with camera position onto selected model elements).





3.4 Common data environment (CDE)

The common data environment (collaboration platform) is an essential basis for handling collaboration in the course of project implementation. In projects, a CDE is usually provided by the client. In the best-case scenario, a professional client handles its entire portfolio on a CDE, thus reducing setup costs while benefiting from the advantages of central data storage and uniform structuring.



A CDE is generally understood to be a web-based platform for collaboration across the entire planning team – this facilitates collaboration between different software applications. For the implementation of collaboration within a specialist discipline, integrated collaboration platforms are used – these permit collaboration within a specific application and offer options such as real-time collaboration and joint working down to the element or even feature level.

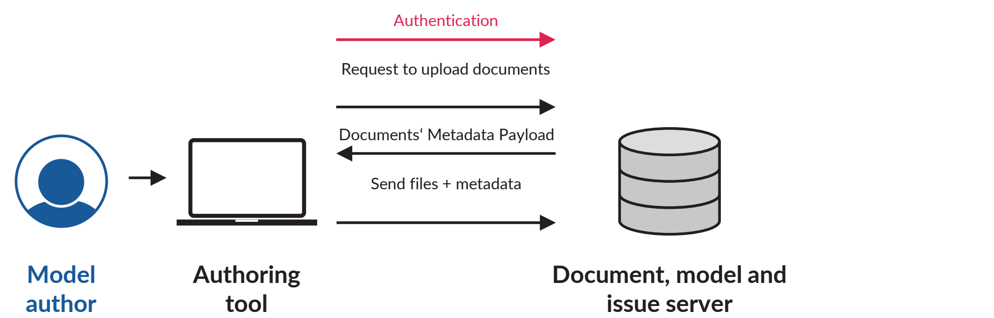
3.4.1 History of development

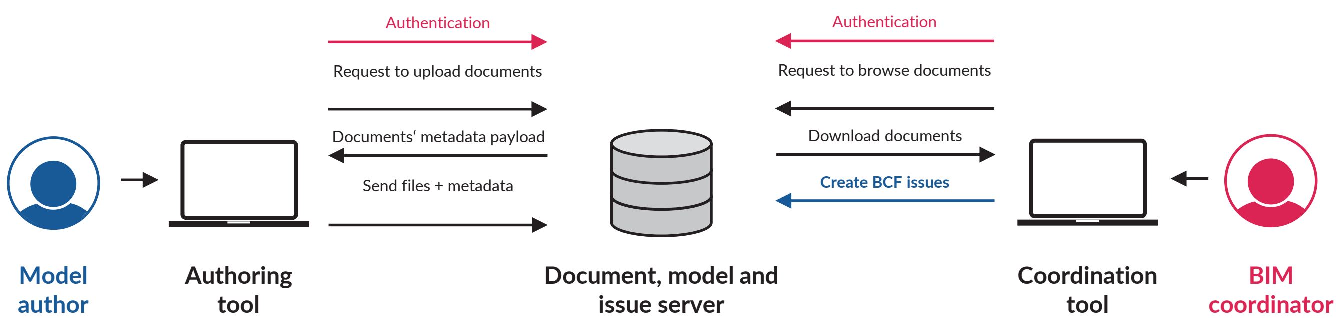
In 2007, the function and structure of a CDE was described for the first time in the British BIM standard PAS 1192 (see QR code). It assumed collaboration on a file basis – which can be realized with simple file-sharing platforms (e.g., Nextcloud). The status of a file was to be declared by being assigned to a folder (Work In Progress, Shared, Published, Archived).

ISO 19650 defines the CDE as the central component of a PIM (project information model) in which all project information is collected, exchanged, and transferred to the AIM (asset information model) for project completion. The underlying structure was taken from PAS 1192, as the ISO 19650 series is based on this standard.

Currently available CDEs offer a significantly more complex range of functions with the integration of project-related (e-mail) communication, file/plan exchange, model/comment exchange, and viewer function. The implementation of the original concept of PAS 1192 is nowadays often realized via status information and file versioning to allow the interaction with workflow functionalities.

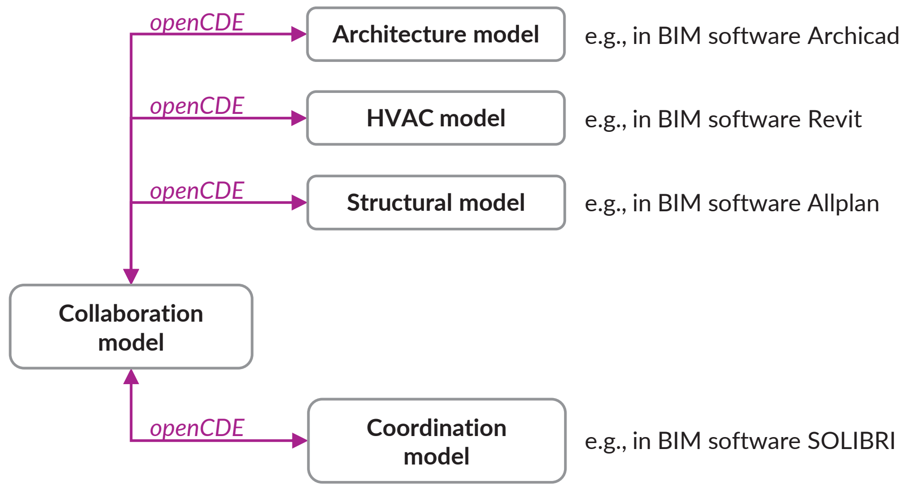
The weak point of CDEs in practice is the high effort involved in providing information. The parties involved have to upload documents, plans, models (IFC), and model comments (BCF) more or less manually to the CDE and declare them accordingly. This sometimes (product-dependent) laborious work is time-consuming and error-prone. The following figure describes the typical effort involved in providing model information in the CDE (top) and in checking and providing the check results (bottom):



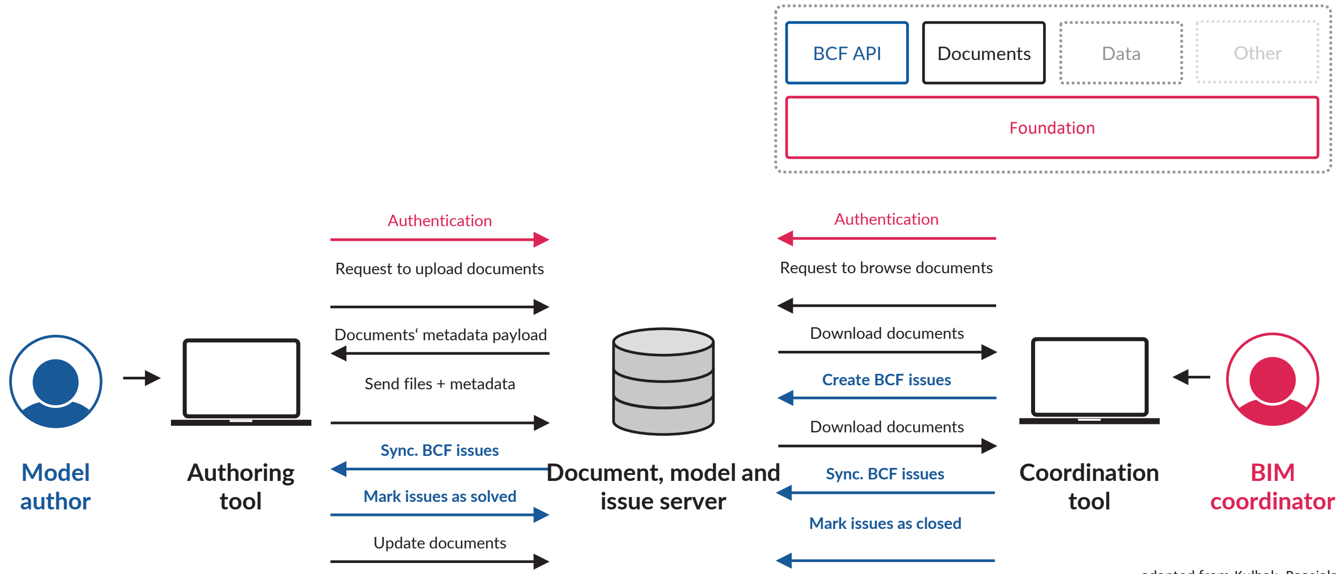


adapted from Kulbak, Paasiala

These disadvantages will be eliminated in the future by using a web-service-based connection of the software applications to the CDE – this technology is currently being developed under the name openCDE (see QR code).



In openCDE, the exchange will no longer be handled at the file level but on the basis of database-driven web services. Manual declarations will no longer be required; only changes will be transferred. This optimizes the data volume and thus the transfer time. The following graphic illustrates the reduced effort in model-based communication (processes marked in bold).



adapted from Kulbak, Paasiala

3.4.2 Objectives of a CDE

The objectives of a CDE are:

- The creation of a unique data environment for a project and its project team, or a data environment for a complete portfolio of various projects and their respective project teams. Advantage: rapid availability of information, unambiguous retrievability of information, central evaluability of all projects (for portfolio).
- Ensuring the necessary data security through encrypted data transmission, user authentication, multiclient capability, role-based user concept. Advantage: ensuring the necessary discretion over sensitive information, guaranteeing compliance with legal requirements.
- The consistent and uniform structuring of all project information (also across projects). Advantage: facilitated project management due to the easier evaluability of project status, easier comparability of project information.
- The uniformly controlled implementation of project processes (also across projects). Advantage: simplified project management due to predefined processes with clear responsibilities and traceable communication.
- Fast and accurate collection of the project status via predefined characteristic values (also across projects). Advantage: facilitated project management.
- Facilitated identification of relevant project content/procedures for archiving or for compact transfer of relevant project content/procedures for archiving upon project completion.
- Facilitating the identification of relevant project content/processes for operations management or compact transfer of relevant project content/processes to operations management or the AIM at relevant times.

3.4.3 Criteria for CDEs

A CDE is a central data room for all project information. Its operation is therefore subject to data protection criteria and the warranty claims that must be taken into account. The CDE is often made available on the provider's hardware because the customer does not have the necessary technical capacity and security in its own IT structures. In such cases, the client must check both the conformity of the provider's service with data protection law and its conformity with the required warranty claims for availability, fail-safety, physical access, incompatibility of the dependency on third parties, etc. Such requirements are often not fulfilled in currently advertised cloud offerings, and the advantages and disadvantages must be carefully examined.

3.5 Levels of detail (LOD, LOG, LOI)

This section describes the content and the relationships of the levels of detail. They are an essential part of the technical guideline within the EIR and BEP regulations. The levels of detail are part of the requirements of a company and serve as the basis for the smooth process flow within a project – however, they are not standardized. The LOG and LOI levels of detail are mandatory in the EIR and BEP sets of rules as specifications for model data implementation and data delivery. The levels of detail LOD and LOC serve as a classification and coordination aid with regard to the model data within the projects.

The individual levels of detail conform to the definition of terms of Platform 4.0 (for Austria): (NB: Descriptions have been partially updated compared to Platform 4.0)

LOD – The level of development describes the project-phase-related level of development of components. It is made up of the LOC, the LOG, and the LOI of the components.

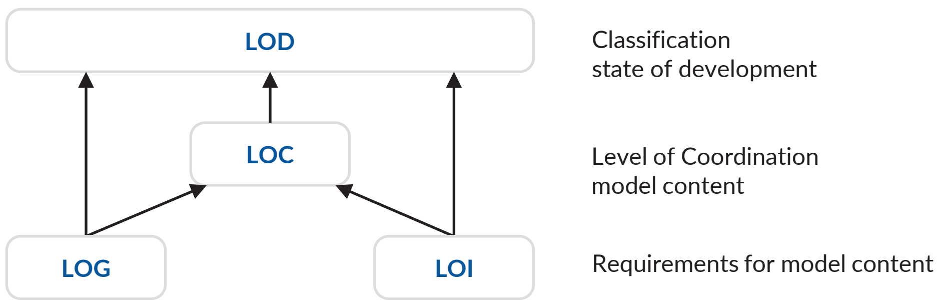
LOC – The level of coordination provides information about the level of coordination of a building element depending on the project phase. It is determined internally (per discipline) and superordinately (across disciplines) via the LOG and LOI to be used. The LOC can assume only two values, namely »true« or »false«.

LOG – The level of geometry (information requirement) refers to the geometric requirements for the representative representation of building elements or their detailing. The specifications of the LOG give users of BIM software precise guidelines on the level of detail of the building elements of a planning model depending on the project phase.

LOI – The level of information refers to the alphanumeric requirements for building elements. The specifications of the LOI give users of BIM software precise guidelines on the level of information of the building elements of a planning model depending on the project phase.

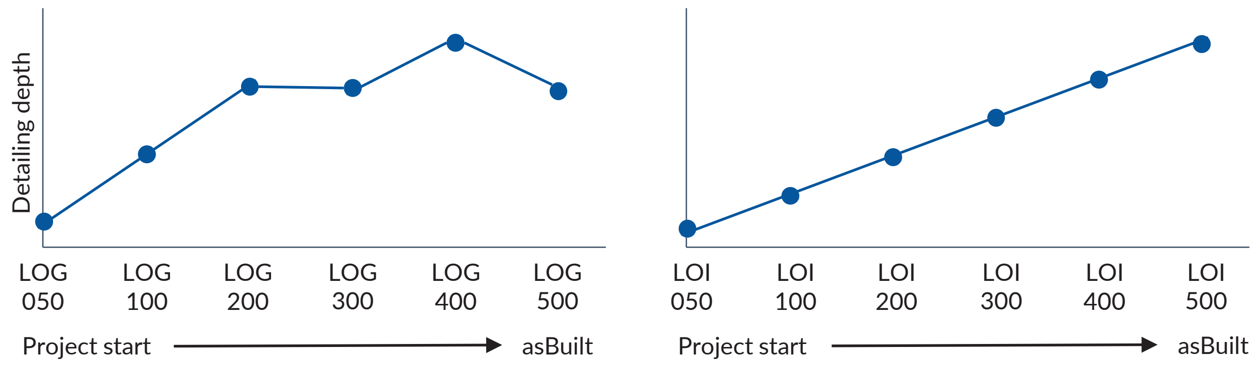
The levels of detail are hierarchical and directly related to each other as shown in the following figure:

Hierarchy



The LOG and the LOI have the highest degree of recognition within the levels of detail. They define the information requirements of the customer which must be implemented by the project participants. The EIR contain the basic set of information requirements, which can be modified in the BEP for each project. The content of both levels of detail should be examined in detail at the start of the project and discussed with regard to feasibility and accountability.

The development of the level of detail of the LOG and the LOI can be abstracted as shown below:



While the level of detail of the alphanumeric requirements in the LOI increases steadily, the level of detail of the LOG may be partially constant (e.g., between LOG200 for design and LOG300 for submittal planning) or even decrease at the time the asBuilt model is handed over to facility management.
Specifically, the levels of detail of the LOG and the LOI define for the model content WHAT > HOW + WHEN + WHO must be transferred:

- WHAT establishes the element reference via the IFC entity
- HOW describes the information request
- WHEN is mapped in a phase-related manner by LOG and LOI classes 050 to 500
- WHO is defined by the responsible discipline

The following example from the EIR of buildingSMART Austria describes the requirements of LOG classes 050 to 500 (in German):

LOG-Klassen AR-Modell

Nachfolgende Tabellen beschreiben die LOG-Klassen der IfcArchitectureDomain[30].

	Phasenbezug					
LOG-Klasse	**LOG050**	**LOG100**	**LOG200**	**LOG300**	**LOG400**	**LOG500**
Raumstempel/ BGF	Jede Einheit als Volumenkörper zur Definition von BRI/BGF	Jeder Raum als IfcSpace zur Definition der NRF gem. ÖN B1800 / SIA416 BZW. D0165. Geschossweise getrenntes Gebäudevolumen als IfcBuildingElementProxy zur Definition von BRI/BGF.	Jeder Raum als IfcSpace zur Definition der NRF und der UGF gem. ÖN B1800 / SIA416 bzw. d0165. Geschossweise getrenntes Gebäudevolumen als IfcBuildingElementProxy zur Definition von BRI/BGF.	Jeder Raum als IfcSpace zur Definition der NRF und der UGF gem. ÖN B1800 / SIA416 bzw. d0165. Geschossweise getrenntes Gebäudevolumen als IfcBuildingElementProxy zur Definition von BRI/BGF.	Jeder Raum als IfcSpace zur Definition der NRF und der UGF gem. ÖN B1800 / SIA416 bzw. d0165. Geschossweise getrenntes Gebäudevolumen als IfcBuildingElementProxy zur Definition von BRI/BGF.	Jeder Raum als IfcSpace zur Definition der NRF und der UGF gem. ÖN B1800 / SIA416 bzw. d0165. Geschossweise getrenntes Gebäudevolumen als IfcBuildingElementProxy zur Definition von BRI/BGF.
Komplexität Vertikale Bauelemente	nicht relevant.	Tragende/nichttragende Wände einschichtig modelliert.	Tragende/nichttragende Wände mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit PH/TWP.	Tragende/nichttragende Wände mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit PH/TWP.	Tragende/nichttragende Wände mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit PH/TWP.	Tragende/nichttragende Wände mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit AF.
Komplexität Horizontale Bauelemente	nicht relevant.	Tragende Decken inkl. Bekleidungen einschichtig modelliert.	Rohdecke sep. modelliert. Bekleidungen (FBA/AGD/UD) raumspezifisch/mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit PH/TWP.	Rohdecke sep. modelliert. Bekleidungen (FBA/AGD/UD) raumspezifisch/mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit PH/TWP.	Rohdecke sep. modelliert. Bekleidungen (FBA/AGD/UD) raumspezifisch/mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit PH/TWP.	Rohdecke sep. modelliert. Bekleidungen (FBA/AGD/UD) raumspezifisch/mehrschichtig modelliert, inkl. aller relevanter Schichten ab 1cm, in Abstimmung mit AF.
Sonstige Bauelemente	nicht relevant.	Tragende Stützen/Träger modelliert.	Tragende/nichttragende Stützen/Träger inkl. Bekleidungen modelliert. Brüstungen/Geländer mit Basisgeometrie modelliert.	Tragende/nichttragende Stützen/Träger inkl. Bekleidungen modelliert. Brüstungen/Geländer mit Handlauf modelliert, Sonderbauteile deklariert.	Tragende/nichttragende Stützen/Träger inkl. aller relevanter Schichten ab 1 cm modelliert. Brüstungen/Geländer mit Handlauf modelliert, Sonderbauteile deklariert.	Tragende/nichttragende Stützen/Träger inkl. aller relevanter Schichten ab 1 cm modelliert. Brüstungen/Geländer mit Handlauf modelliert, Sonderbauteile deklariert.
Treppen/ Rampen	nicht relevant.	Treppen/Rampen mit Basisgeometrie einschichtig modelliert.	Treppen/Rampen mit Basisgeometrie inkl. Bekleidungen modelliert.	Treppen/Rampen mit Basisgeometrie inkl. Bekleidungen modelliert.	Treppen/Rampen inkl. aller relevanter Schichten ab 1 cm modelliert inkl. Entkoppelung.	Treppen/Rampen inkl. aller relevanter Schichten ab 1 cm modelliert inkl. Entkoppelung.
Erschliessungs-Elemente (bspw. Aufzugsanlage/ Rolltreppe)	nicht relevant.	Als schematisches Objekt	Als schematisches Objekt	Als schematisches Objekt	Als ausformuliertes Objekt	Als Hersteller-Objekt.

For each discipline, there is a description for the respective LOG class and element type and how this element type must be geometrically formulated in the model (modeling specification).

The following example from the EIR of buildingSMART Austria describes the requirements for LOI classes 100 through 400 (in German):

LOI-Klassen AR-Modell

Wand (Beispiel)

Folgende Tabelle beschreibt die benötigten Merkmale der Elementklasse Wand (IfcWall[22]) in Abhängigkeit der LOI-Klasse. Der PredefinedType[23] ist verpflichtend zu deklarieren. Das Pset_WallSpecific muss in der BIM-Applikation angelegt werden. Es enthält Merkmale die zusätzlich zur buildingSMART-Struktur angegeben werden.

LOI-Klasse	MERKMALE ÜBERSETZUNG DE	MERKMAL-NAMEN	EINHEITENTYP	EINHEIT	VERORTUNG	VERANTWORTUNG
LOI100	Aussenbauteil	IsExternal	Wahrheitswert	TRUE/FALSE	Pset_WallCommon	AR
	RaumhoheWand	ExtendToStructure	Wahrheitswert	TRUE/FALSE	Pset_WallCommon	AR
	Status	Status	Text (Optionen-Set[24])	-	Pset_WallCommon	AR
	TragendesElement	LoadBearing	Wahrheitswert	TRUE/FALSE	Pset_WallCommon	AR/TWP
LOI200	BrandabschnittsdefinierendesBauelement	Compartmentation	Wahrheitswert	TRUE/FALSE	Pset_WallCommon	BS
	BrennbaresMaterial	Combustible	Wahrheitswert	TRUE/FALSE	Pset_WallCommon	BS
	Feuerwiderstandsklasse	FireRating	Text (Optionen-Set[24])	-	Pset_WallCommon	BS
	UWert	ThermalTransmittance	Wärmedurchgangskoeffizient	positive Zahl [W/m²K]	Pset_WallCommon	PH
LOI300	Brandverhalten	SurfaceSpreadOfFlame	Text (Beispiel [25])	-	Pset_WallCommon	BS
	Schallschutzklasse	AcousticRating	Text (Beispiel [26])	-	Pset_WallCommon	PH
LOI400	Ausfuehrung	ConstructionMethod	Text (Optionen-Set[24])	-	Pset_ConcreteElementGeneral	AR/TWP
	Betonart	TypeOfConcrete	Text	-	Pset_WallSpecific	AR/TWP
	BewehrungsgradFlaeche	ReinforcementAreaRatio	Bewehrungsgrad	positive Zahl [kg/m²]	Pset_ConcreteElementGeneral	AR/TWP
LOI500	- Noch zu definieren. -					

Tabelle 80: LOI-Klassen Elementklasse Wand

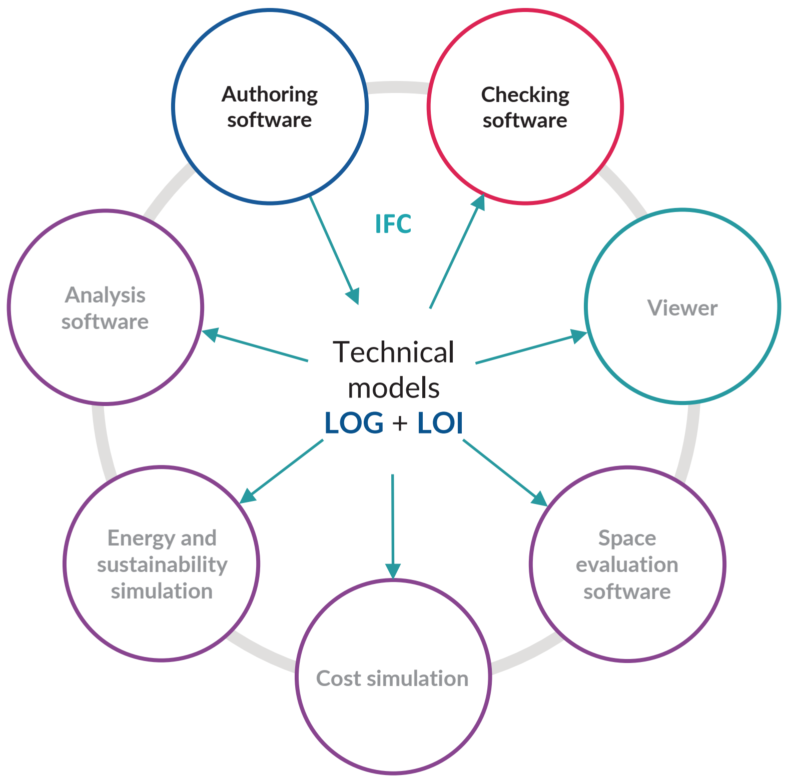
For each element class (entity), there is a set of alphanumeric requirements (= characteristics) for the respective LOI class, which an entity must contain at the end of the phase. Besides the standard data content of the IFC data structure (specific Pset content), the specific feature requirements are also defined.

The LOG and LOI levels of detail thus contain the geometric and alphanumeric content requirements for the domain models for data exchange and further use of the model data. The requirements are adopted in the respective authoring software and implemented in the model data = creation of the model content. Both LOG and LOI serve as an important basis for quality assurance for the BGK and BFK teams. They form the basic framework that the check content in the checking software refer to in a phase-dependent manner. The following checking routines are executed:

- **FCC – formal criteria**
- **QCC – quality criteria**
- **ICC – integrity criteria.**

They access the information in the LOG and LOI.

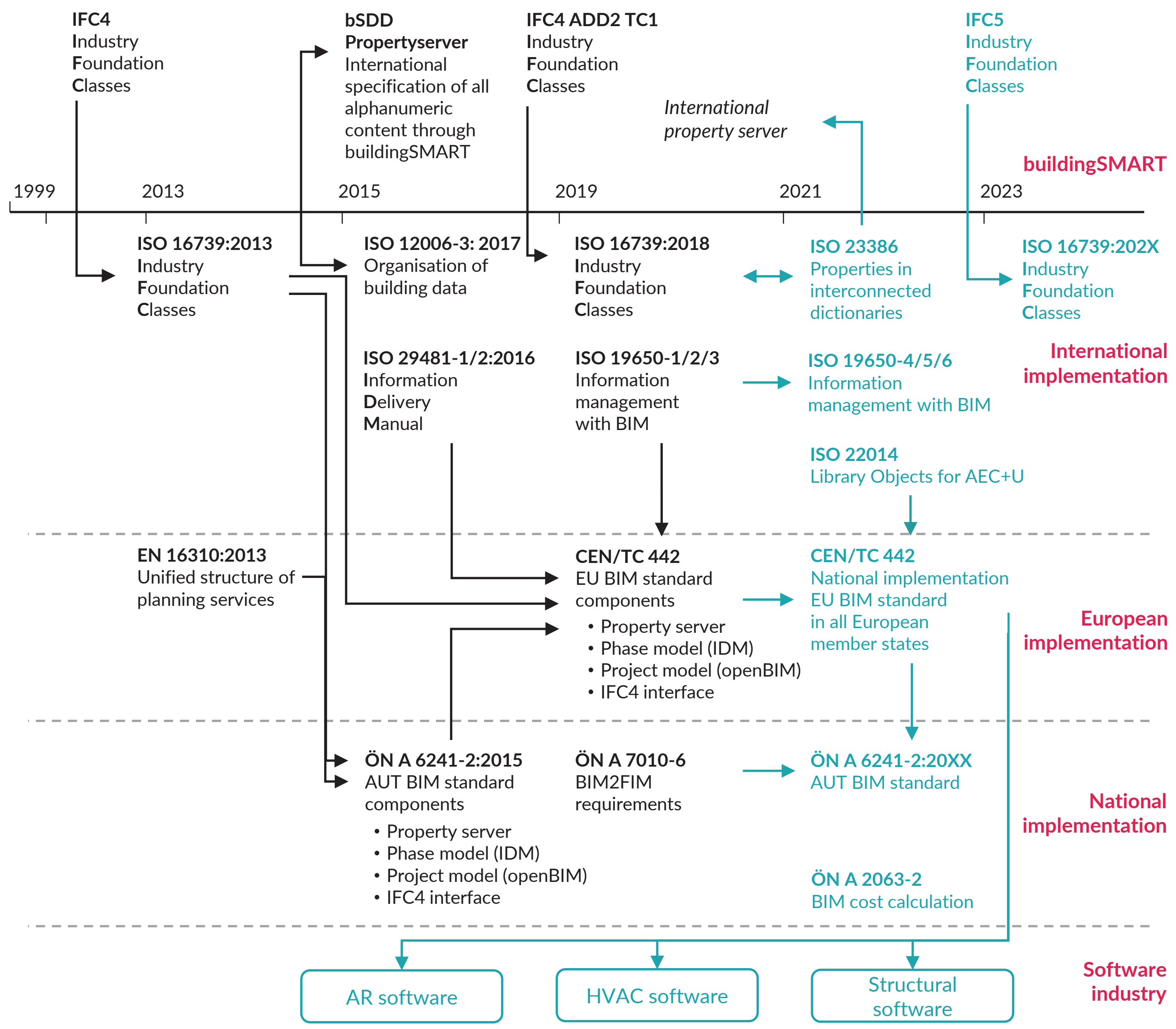
The use of the model content in other software (e.g., space layout program, evaluation program, etc.) is carried out only by means of checked and BGK-approved domain models and also with the aid of the content of the LOG and LOI:



3.6 Standardisation

This section provides an overview of the main openBIM standards and their development at the national, European and international level. The standards mentioned in Chapter 2 are related to each other and an outlook on planned standardisations is given:

Overview of the standardisation



The figure above shows the dependencies of the various standards on each other in chronological order. The basis for the use of openBIM is the manufacturer-neutral data structure IFC4, which was developed by bSI and certified in 2013 as ISO standard ISO 16739:2013 »Industry Foundation Classes (IFC) for data exchange in the construction industry and plant management«. IFC provides the data structure for the exchange of geometric and nongeometric (alphanumeric) information. Alphanumeric information is transported primarily via IfcPropertySet. The standardized IfcPropertySet definitions are not anchored in the IFC schema; buildingSMART provides them as a separate specification. They are managed in the international feature server bSDD, which is based on ISO 12006-3:2017 »Organization of data on structures«.

Now that the information structure has been standardized, the following question arises: In what form should the data be output by the software manufacturer? This is defined by using the model view definition (MVD) with which software manufacturers are certified by bSI. The development of the MVD is carried out by the information delivery manual (IDM). In an IDM, process representations are used to define what information a model contains. This method is certified in ISO 29481-1/2:2016 (»Information Delivery Manual«). The next step after the standardisation of the data structure and data exchange is the standardisation of the information management with BIM in standards ISO 19650-1/2/3.

The graphic above also represents the influence of IFC4 standardisation and of the standardisation of a uniform outline of planning services in EN 16310:2013 on the national BIM standard (ÖNORM A 6241-2:2015), which in turn influenced the European working group for BIM developing CEN standards (CEN/TC 442). These CEN standards are to drive the standardisation of openBIM in the next few years and also exert stronger pressure on software manufacturers than national standardisations.

The international and European standards under development will have a particular influence on alphanumeric data exchange (keyword: DataTemplate) and on the AVA process (particularly ÖNORM A 2063-2).

3.6.1 ISO 16739:2013

As an independent association, bSI develops its own standards. The best known is IFC, which allows the international exchange of model information. The current version (IFC4) was published as ISO 16739 in March 2013 and is continuously being developed. The exact data structure is described in Section 3.1.

3.6.2 EN 16310:2013

At the European level, EN 16310:2013 was also published in 2013. This standard deals with the uniform classification of planning services. Terms relating to engineering services are defined. The aim is to promote free competition in the EU by means of a glossary of key terms from the construction industry that is harmonized at the European level. At the same time, problems in cross-border cooperation resulting from different interpretations of relevant terms in the various European countries are to be reduced. The focus is on the entire engineering services sector (construction of buildings, infrastructure, and industrial plants). The life cycle of structural facilities is divided into six sections which are subdivided into subsections:

			Stages	Sub Stages
Before use stage	Product stage	0.	Initiative	0.1 Market study 0.2 Business case
		1.	Initiation	1.1 Project initiation 1.2 Feasibility study 1.3 Project definition
		2.	Design	2.1 Conceptual design 2.2 Preliminary design and developed design (B&I) 2.3 Technical design or FEED 2.4 Detailed engineering
		3.	Procurement (IF)	3.1 Procurement 3.2 Construction contracting
	Construction stage	4.	Construction	4.1 Pre-construction 4.2 Construction 4.3 Commissioning 4.4 Hand over 4.5 Regulatory approval
Use stage		5.	Use	5.1 Operation 5.2 Maintenance
End-of-life stage		6.	End-of-life	6.1 Revamping 6.2 Dismantling

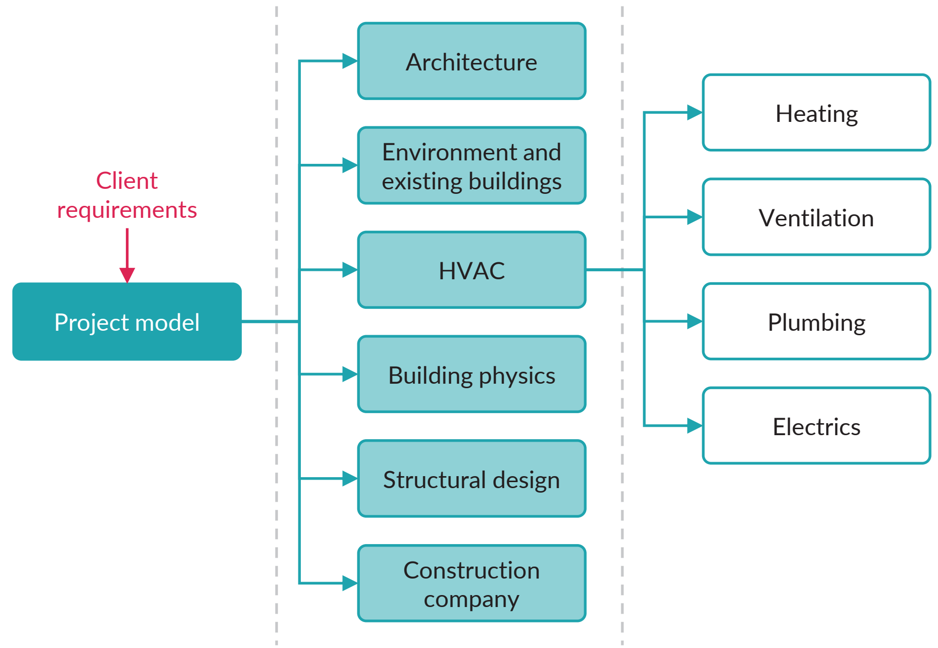
This outline and the IFC data structure influenced the preparation of ÖNORM A 6241-2 »Digital building documentation – Part 2: building information modeling (BIM) – Level 3 – iBIM«.

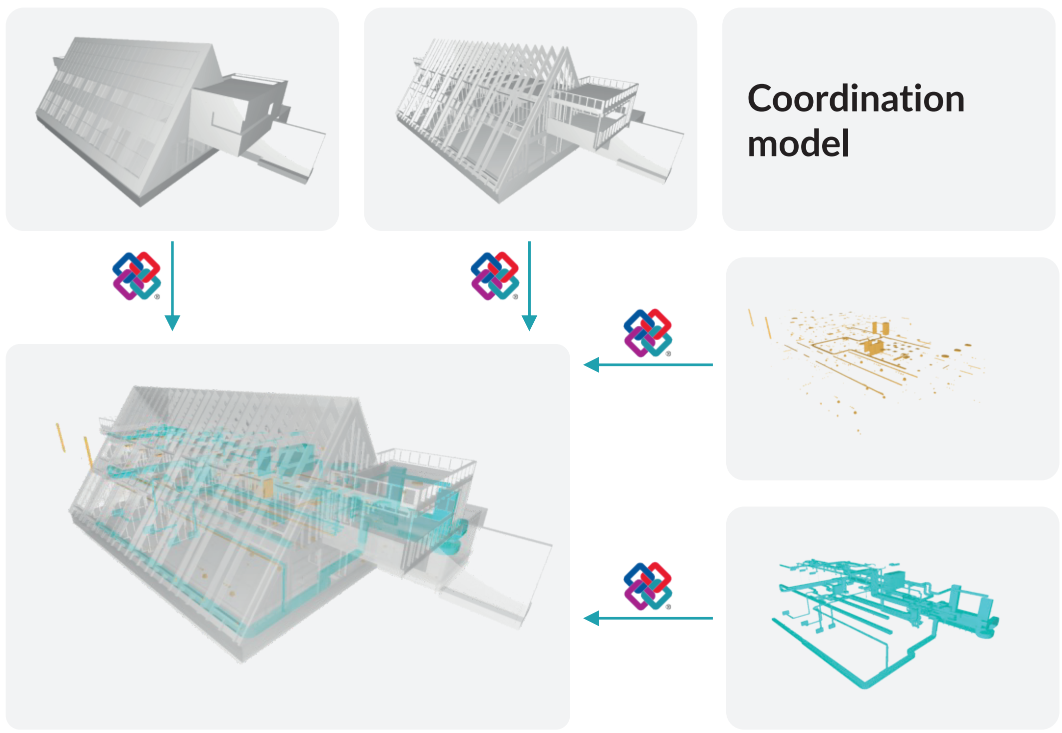
3.6.3 ÖNORM A 6241-2

ÖNORM A 6241-2 is a part of the separate digital standardisation group A 6241. While the focus of ÖNORM A 6241-1 is on the general exchange of CAD data (e.g., clear naming of layouts and blocks), ÖNORM A 6241-2 deals with the openBIM methodology. It regulates the technical implementation of a uniform, structured, multidimensional data model for building structures based on building information modeling level 3 – iBIM. This standard forms the basis for a comprehensive, uniform, product-neutral, and systematic exchange of graphical data and the associated factual data based on IFC and bSDD. With the release of this BIM standard, Austria became one of the BIM pioneers in Europe.

ÖNORM A 6241-2 was published before ISO 19650-1. As a result, the terms of the two standards are different. When they are first mentioned in this book, the terms according to ISO 19650-1 are therefore shown in parentheses after the respective terms from ÖNORM A 6241-2. Chapter 7 »Levels of detail« in ÖNORM A 6241-2 is currently being revised.

The first section of the standard defines general terms. This is followed by a description of the project model (PIM). A project model is created on the basis of the client's requirements (EIR). It consists of partial models (specialized models) which can be divided into submodels:





Chapter 3 – Advanced knowledge

3.6 Standardisation

The detailing depends on the life phase of a building. The life phases are defined in accordance with ÖNORM EN 16310, which are compared in »Annex B Allocation of life phases«. Annex C describes the exact life-phase-dependent levels of detail.

The last chapter of the standard describes the IFC data schema (at the time of publication of the standard IFC2x3) as the software-manufacturer-independent standard for the exchange of information in the construction industry. The annex also contains a rudimentary modeling guide.

The following standards are expected to be released in the next few years:

- ÖNORM A 6241-3 »Digital building documentation – Part 3: Building information modeling (BIM) – BIM-based computer aided facility management (CAFM)«,
- ÖNORM A 6241-4 »Digital building documentation – Part 4: Building information modeling (BIM) – Building automation«, and
- ÖNORM A 6241-10 »Digital building documentation – Part 10: Building information modeling (BIM) – Definitions and fundamentals« (based on document 08 »BIM terms and the digitalisation of platform 4.0«)

3.6.4 ÖNORM A 7010-6

ÖNORM A 7010-6 was published in 2019 and describes the information requirements of clients and operators for BIM projects. This description is provided generically in tabular form for typical location elements (such as plots, buildings, and floors) as well as equipment elements relevant to operation (such as doors, windows, and relevant components of ventilation systems/fire alarm systems). Defined are all relevant details that are necessary for maintenance, care, inspection as well as repair or replacement. The subsequent description of the actual implementation based on the IFC specification is taken from the as yet unpublished standard ÖNORM A 6241-3.

3.6.5 ISO 12006-3:2017 (bSDD property server)

The bSDD is complementary to the IFC data structure. It is a web-based service for the creation and consolidation of individual data structure supplements (ontologies) based on ISO 12006-3, which defines the IFD (International Framework for Dictionaries). The IFD is a framework for defining classification systems. The basic principle is that all concepts can have a name and a description (regardless of language). However, only a unique identification code is utilized for identification and use. By attaching labels in multiple languages to each concept, a multilingual dictionary is created.

3.6.6 ISO 29481-1/2

The IDM methodology is certified in ISO 29481-1/2, which supports the description of information requirements for the processes within the life cycle. MVDs are developed on the basis of this IDM.

Chapter 3 – Advanced knowledge

3.6 Standardisation

3.6.7 ISO 19650-1/2/3

ISO 19650-1, ISO 19650-2, and ISO 19650-3 contain process specifications that define BIM services and their implementation. Part 1 contains the description of terms and principles. Part 2 describes information management in the design, construction, and commissioning phases. Part 3 includes the operational phase of assets (real estate).

3.6.8 Planned standardisation

In the next years, several standards on the topic of openBIM are planned to be released at the national, European, and international level:

- ÖNORM A 2063-2 – BIM costing; development of a BIM element catalog
- ISO 23386 – Properties in interconnected dictionaries
- ISO 19650-4/5/6 – Information management with BIM
- ISO 16739:202X – Industry Foundation Classes (IFC5)
- EN development of new European standards on the basis of the CEN/TC 442 working group

BIMcert Handbook 2021

4 BIM project implementation

This chapter provides an in-depth insight into BIM project execution in practice in the various life cycle phases of a building (according to ÖNORM A 6241-2): project initiative, project initiation, planning, tendering, awarding, and construction. It explains the necessary functional steps and activities for openBIM project implementation.

- Relevant for BIM practitioners and BIM experts who want to take a closer look at the individual phases of openBIM use in BIM projekt implementation.
- Relevant for all those who want to take the BIMcert practitioner certification exam (equivalent to "Professional Certification - Practitioner").
- Prior knowledge of the contents of Chapter 1, Chapter 2, and Chapter 3 is assumed.

The processes presented in this chapter should always be considered in conjunction with the rules and regulations (EIR, BEP) and service specifications LM BIM, which are provided free of charge by buildingSMART Austria and buildingSMART Switzerland.

Overview of the BIM organizational structure

Section 2.4 provided an introductory description of the roles in the openBIM process. This section puts these roles into the context of the BIM organizational structure. The detailed description of BIM project execution is provided in the following sections.

The next two figures provide an overview of the basic BIM organizational structure during the planning and construction phases, respectively. However, an individual organizational structure according to the project-related framework conditions may have to be developed for each project.

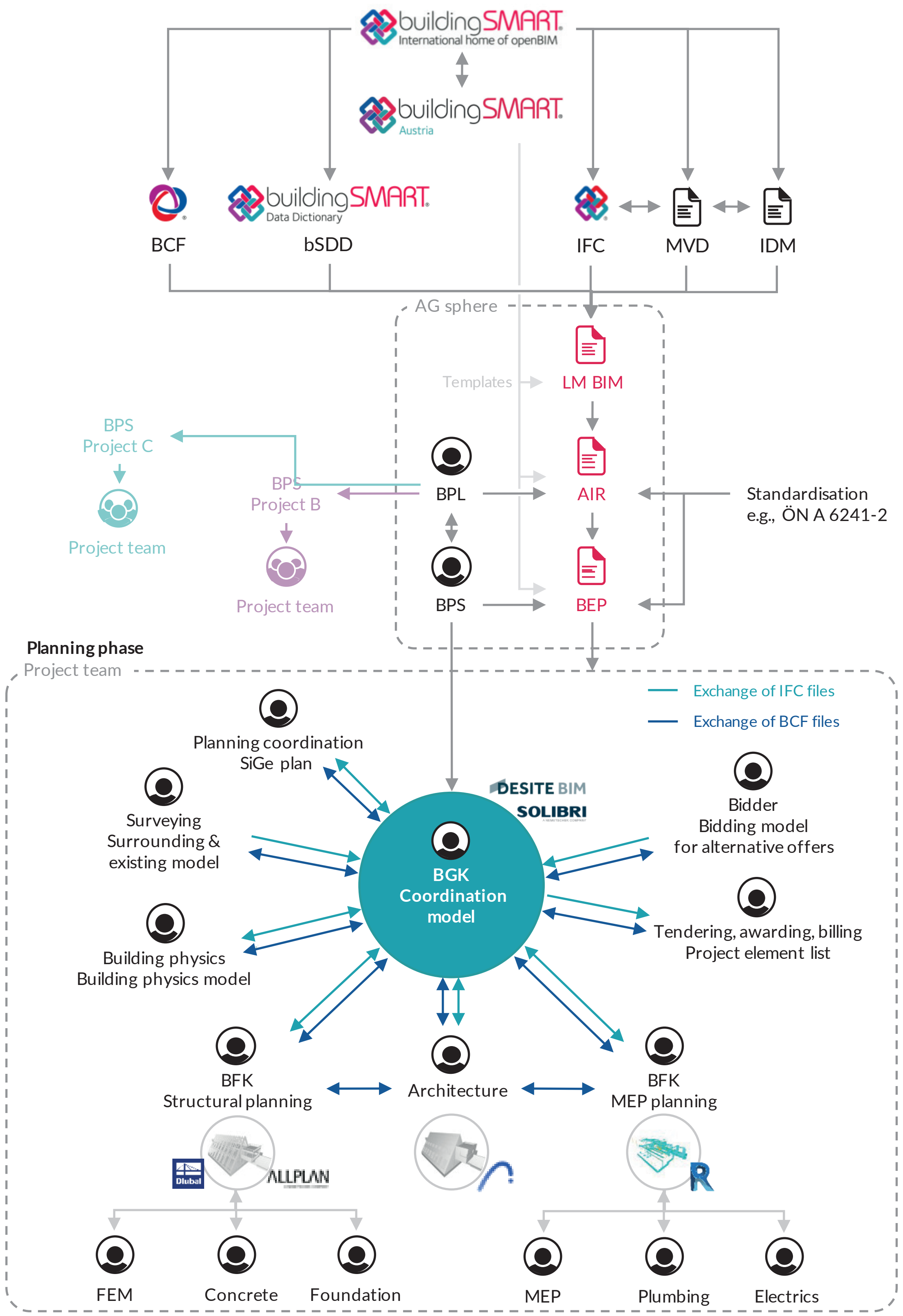
The BIM project management (BPL) represents the interests of the client (AG) with the BIM project control (BPS). The BPL is responsible for specifying the framework conditions of the project, defining the service profiles used by the respective players and enforcing the client requirements for the data structure used in the project. It is subject to the creation of the exchange information request (EIR), in which the information needs of the AG are mapped. The EIR should also define and include the information requirements for operation. Within the framework of openBIM, the specifications regarding the data to be supplied and the interfaces for data exchange are defined on the basis of the buildingSMART standards. Templates for sets of rules and performance specifications are provided by buildingSMART Austria. The topic of standardisation is described in Sections 2.5 and 3.6.

The BPS is responsible for the operational execution of the BIM project within the framework of the specifications of the BPL. It concretizes the EIR within the framework of the BIM execution plan (BEP). This forms the basis for the BIM-based collaboration. The BEP should be part of the contract between the client and

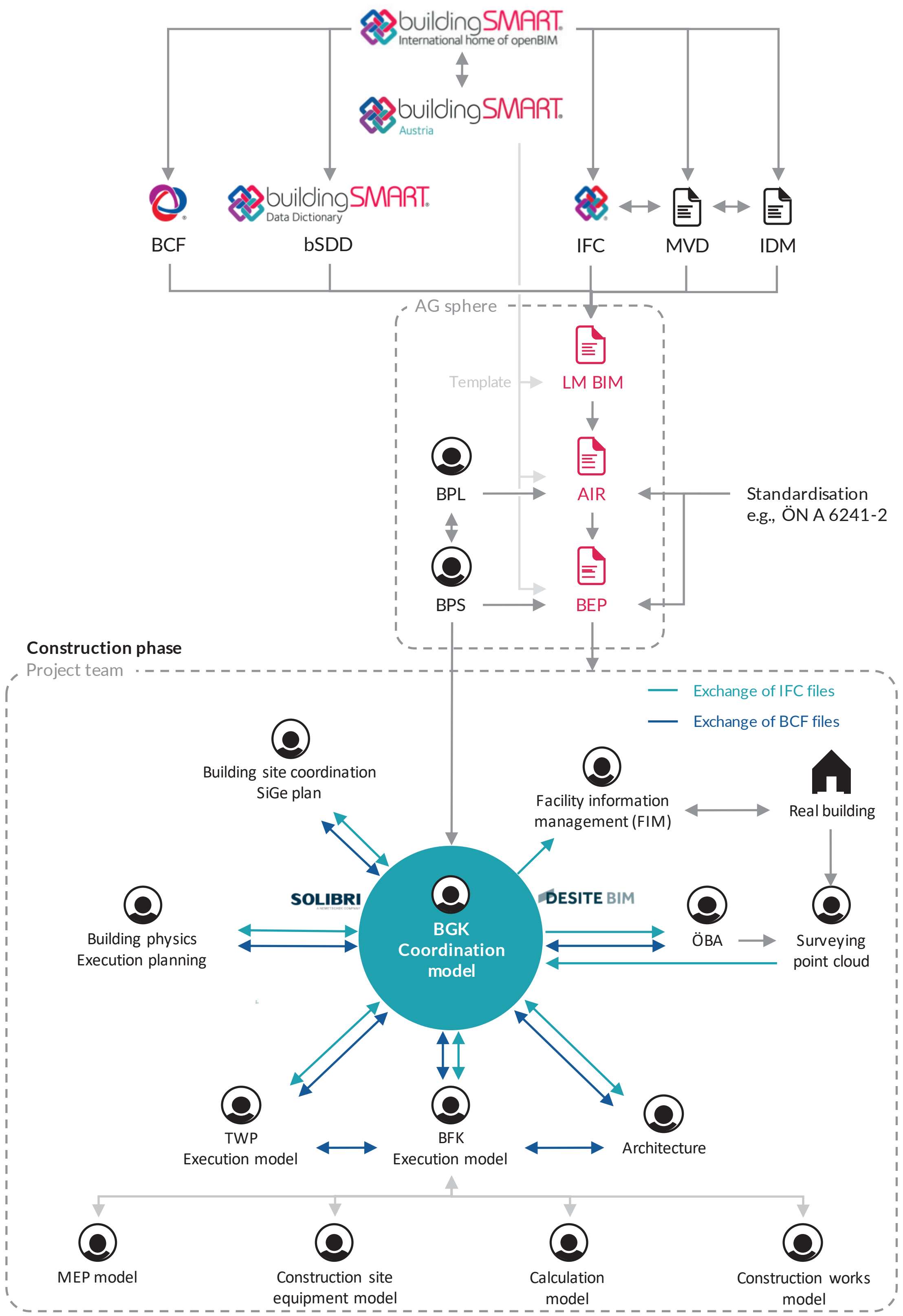
the project team. The interdisciplinary BIM content of the project team is coordinated and verified by the person responsible for overall BIM coordination (BGK). This is the contact person for digital planning alongside the BPS. The BGK team is responsible for the coordination model and supervises the execution of the tasks of the specialist coordinators. The BIM specialist/technical coordination (BFK) verify subject-specific BIM content of the individual disciplines.

The next figure shows the project team with the project participants during the planning phase. The surveying team creates an environment and asBuilt model, which is available as a basis for architecture, structural design, technical building equipment, and building physics. The different planning disciplines create specialized models. The BGK team merges these various domain models into a coordination model. The project participants exchange reference models with each other. In an openBIM process, this exchange of IFC files is also carried out by the BGK team. However, depending on the agreement, the transmission can also take place directly between the trades. The model-based communication between the project participants is carried out using the BCF. During coordination, the safety and health protection plan (SiGe-Plan in Austria) of the planning coordinator is taken into account. Currently, the planning coordinator does not create an own model for this plan. Based on the coordination model the tendering, awarding, and contracting can take place. In addition to the modeled elements, the tender model must also take into account elements relevant to the standardized specifications for building construction (LB-HB), e.g., the construction site equipment. Any alternative bids can result in a bid model. Currently, a structure for a list of elements (AVA elements) is being developed to be published in ÖNORM A 2063-2, which is to link the model with the standard service descriptions.

The second figure shows the project team of the execution phase. Within the scope of execution planning, execution models for architecture, structural design, building services, building physics, site equipment, and costing and auxiliary construction measures as well as a SiGe plan are created. The assigned surveying team develops the asBuilt documentation during construction. The coordination of the surveying operation on the construction site is carried out by the ÖBA. Automation is used to compare the resulting point clouds with the domain models. The BGK team identifies and coordinates any deviations, and documents the result in the model. The result is a complete documentation of the asBuilt status by means of the updated domain models. This asBuilt status is transferred to the facility information management (FIM) including the updated domain models and technical documentation.

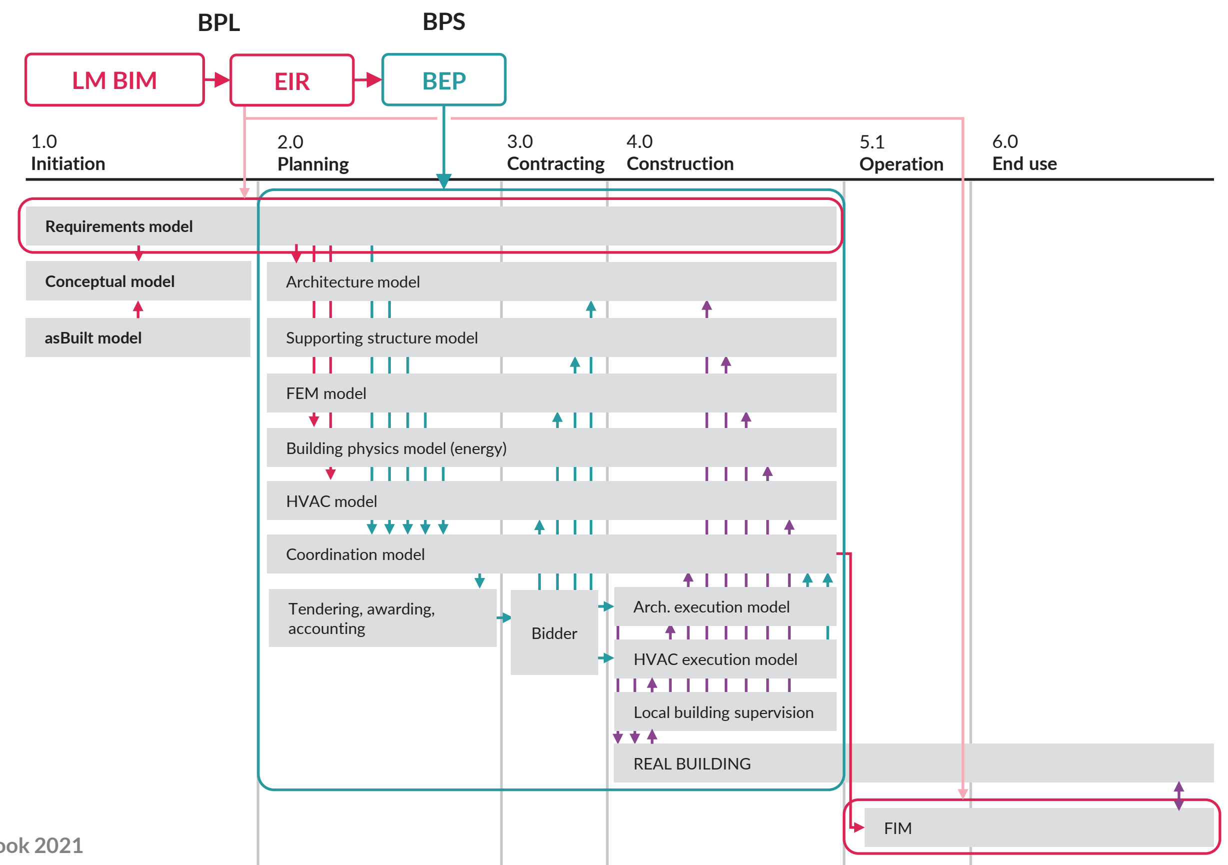


© Urban, Ratz, Gerger



© Urban, Ratz, Gerger

This chapter is structured according to the life cycle phases of project initiative, project initiation, planning, tendering, awarding, and construction. The following figure depicts the organizational structure described above according to the life phases. The basis for the EIR is formed by the service specifications. The LM BIM and EIR are created in the project initiation life cycle phase once the project organization structure has been defined. The EIR include requirements regarding data structure, levels of detail, interfaces, designations, data transfer, and collaboration platform. These also take into account the requirements from operations. In the next step, the BPS creates a BEP template which builds on the project-specific EIR and specifies them in terms of the exact sequence needed for implementing the EIR specifications. The project initiation life cycle phase is concluded by the BEP colloquium, in which the specifications are evaluated by the planning team for model-based project implementation (BEP) on the basis of a BEP template. The BEP forms the basis for all communication, data exchange, and control in the planning, contracting, and construction life phases. The BEP is kept up to date throughout all life cycle phases and, if necessary, adapted under the leadership of BPS and in consultation with the project team in order to meet the requirements. Based on these requirements (red arrows), in the planning phase the domain models are created and combined in the coordination model (turquoise arrows in the planning phase). The bidder information supplements the domain models in the course of awarding the contract (turquoise arrows).
In the erection phase, the domain models are updated according to the asBuilt status (purple arrows). This asBuilt documentation is handed over by the BGK team to the FIM according to the client's requirements (red arrows).



4.1 Project initiative

The life cycle phase 0.0 »Project initiative« (according to ÖNORM A 6241-2, Annex B) is about basic project development. In this life cycle phase, the client develops the basic specifications on which the project is based. In the course of the process described in this section, the general decision-making process for project implementation takes place – here, the results achieved are used to evaluate the extent to which the project idea can actually achieve the goals and the framework specifications defined by the client, or to assess which capabilities are expected.

4.1.1 Determination of the project-related objectives

This activity is performed at a very early stage of the project by BPL or BPS and serves to focus the work of future contractors on customer benefits.
In the first step, the AG defines the strategic objective. In this strategic document, the AG formulates the investment objective, which shows the reasons for the intended investment. In addition to purely quantitative specifications for the investment framework, qualitative specifications are also defined:

- the strategic intent of the client,
- the definition of the investment type,
- the determination of the intended use,
- the determination of the intended service life (staggered according to primary system, secondary system/MEP, expansion),
- the definition of operational objectives,
- the definition of the economic objectives, and
- the specification of standards to be met or intended real-estate certifications.

The second step is the definition of the operational objective which builds on the framework of the strategic objective. Here, the AG formulates his BIM objectives, which show the reasons for the use of BIM. Usually, each defined objective is supplemented by a compact description of the mode of action.

The third step is the prioritisation of the defined operational goals. On the one hand, this can be done with a simple ranking of the operational objectives according to their importance for the client – or supplemented with a so-called objective matrix, which compares statements on planning-relevant issues that are partially mutually exclusive. The preference determined by the client clarifies his priorities. For example, it can state that the AG generally prefers solutions that lead to low operating costs to those that cause low investment costs – or vice versa. The definition of the objectives is a basic building block of the project concept. This is followed by the definition of the required model content (via LOG and LOI) or the definition of the project-related BIM use cases. This procedure controls the overall direction of the project. The prioritisation of the specifications supports the expression of the client's intentions. In doing so, they strive to achieve an optimal mix of intended objectives (with usable added values) and the real capabilities of the market participants (with the resulting array of bidders).

4.1.2 Determination of the financing model

This determination is made by BPL or BPS at a very early stage of the project and serves to align the expected project results with market requirements.

The definition of the financing model is a basic building block of project conception. Based on this, the definition of the required model content (via LOG and LOI) or the definition of the project-related BIM use cases is subsequently carried out and thus the entire orientation of the project is controlled – in particular with regard to the requirements of later users. Clients strive to achieve an optimal mix of required BIM services (with usable added values) and the real capabilities of the market participants (with the resulting array of bidders).

4.1.3 Reconciliation of the performance indicators

The reconciliation of performance indicators is done by BPL or BPS at a very early stage of the project and is used to determine the success of the project implementation.

In the first step, the AG defines the target area of the measurement. To do so, the already developed objectives are used and a distinction is made between content-related objectives and processing objectives. In the second step, the AG determines the measurement parameters and criteria relevant for the target areas.

The reconciliation of the performance indicators is a basic building block of project design. Based on performance indicators, the success of the project is determined and thus the primary indicator for the project status is defined. Clients strive to find the optimal combination of project-specific focus (with precise, objective results) and cross-portfolio comparability.

4.2 Project initiation

Life cycle phase 1.0 »Project initiation« (according to ÖNORM A 6241-2, Annex B) is focused on the basic project setup. In this life cycle phase, the client develops the basics for project implementation on which the activities of the contractors are based. This life cycle phase starts after the positive evaluation of the project idea.

In the course of this phase of the life cycle, the specifications for project implementation are developed and conceptual studies are carried out, if necessary, for example in the form of an architectural competition. The project phase concludes with the establishment of the BIM organization and relevant steps before the immediate start of project planning.

4.2.1 Identification and compilation of project-related requirements

Project initiation starts with the identification of project-related requirements by BPL and serves to compile these requirements based on company-wide cross-project sets of rules. For institutional clients, the predefined company-wide AIR or EIR (cross-project) serve as the basis. These uniformly declare the general framework requirements with regard to basic uniform specifications for project execution as well as any data transfer (in particular to FM) across all projects (institutional clients are clients who regularly handle construction projects and thus maintain in-house competencies).

In the first step, relevant regulations are identified. The project location, project complexity and corresponding objectives of the customer are decisive criteria. In the second step, these requirements are summarized for each project. They are thus available as a basis for the subsequent project-related establishment of the rules and regulations.

4.2.2 Creation and setup of BIM service specifications, rules and regulations, and contracts

With this activity, BPL and BPS formulate the project-related requirements as sets of rules. Based on this, the performance specifications for contractors are declared in a form that is customary in the market and uniformly comprehensible. They form part of the invitation to tender and later also of the planning contracts.

In the first step, the envisaged basic project organization structure is determined. This has a direct impact on the intended services of the future contractors. Therefore, the second step is to define the service profiles for all relevant organizational units – often carried out cooperatively by the BPL, BPS, BGK, and BFK teams, the BIM designer (BE), and the ÖBA, in order to fully coordinate and clearly delimit the service profiles.

In the third step, the client prepares the EIR based on the service specifications. They define and contain at least the following specifications:

- specifications for the data structure,
- specifications on the levels of detail,
- requirements for the interfaces to be used,
- requirements for the designations to be used,
- requirements for the data transfers to be carried out, and
- requirements for the collaboration platform to be used.

The fourth step is the preparation of the BEP template which serves as the basis for the project setup in the course of the BEP colloquium (see Sections 4.2.8 and 4.2.9). The template builds on the project-specific EIR and specifies it in terms of the exact sequence for implementing the EIR specifications. In the final step, the developed specifications are integrated into the tender documents.

4.2.3 Model-based requirements planning (requirements model)

BPL or BPS now formulate the project-related requirements for the structure to be created. The difference to a conventional space and function program lies in the semantics of the requirements model and the associated machine readability. This allows, on the one hand, for the seamless transfer of the client's specifications by the planning team (= contractor planning, AN planning) to its BIM software application and, on the other hand, for the automation-supported verification of the specifications from the requirements model against the current planning status during the execution of the project. The requirements model is a performance specification for the planning contractor and therefore part of the tender.

The creation of the requirements models is carried out with the help of specially developed software tools such as dRofus or buildingOne. These tools permit the concentrated development of the layout and function programs as well as the corresponding organization of room types including equipment options. They are able to map these specifications in an IFC-based structure. The specifications for the IFC structure are taken from the AIR or EIR and must conform to the data structure to be used later in the project by the planning contractor. Otherwise, a comparison between the requirements model and the planning models is made difficult or impossible.

The requirements model quantitatively maps all spaces to be considered in the planning, including the qualities to be created. These are then responded to by the planning contractor. The requirements model can be initiated by the planning contractor and updated in the planning context. The original requirements model remains the responsibility of the client; the BPL updates it in appropriate cases. A change to the requirements model is traceable and communicated accordingly. Under certain circumstances, this change is a formal amendment to the order and may result in a planning change. The interaction of planning specification with planning implementation thus becomes more transparent and comprehensible.

At a minimum, the comparison of the requirements model with the planning models takes place during the checks for data delivery (QualityGate).

4.2.4 Basic structure (survey, asBuilt model, terrain model)

During the basic design, the BPS team, possibly together with the surveying team, creates the project-related planning basis. The difference to the conventional approach lies in the significantly higher precision of the specification (georeferencing, complete mapping of the existing situation, structural specification, and functional scope). This facilitates the seamless use of the asBuilt information by the planning contractor in his/her BIM software applications. The asBuilt and terrain model are part of the tender and the basis for any conceptual studies or architectural competitions.

4.2.5 Tendering, awarding, and installation of the collaboration platform

In the course of project initiation, BPL and BPS create the central platform for information exchange. Institutional clients use predefined, company-wide, and standardized product specifications as the basis for all projects.

In the first step, the customer identifies the relevant functions. The key criteria here are user rights, the resulting security aspects, the type of project, and the complexity of the project. The second step summarizes these requirements on a project-specific basis. If the client does not require a specific product, the next step is to invite tenders and procure a collaboration platform in accordance with the specifications. Once procurement/awarding has been completed, the third step is the project-related setup. The organizational unit responsible for this is the one that will later be responsible for project management (usually BPS).

At present (2020), the functional scope of current collaboration platforms often does not include bidirectional, web-service-based handling of model-based communication (BCF). This feature is only to be expected to be available with the spread of openCDE. Therefore, it is currently common practice to set up and use a communication platform alongside the collaboration platform. The conditions for the procurement and setup of the communication platform are the same as those for the collaboration platform.

4.2.6 Tendering and awarding of planning services

BPL and BPS identify the best bidder for the design services.

In the first step, they compile the previously developed basics (rules and regulations, performance profiles, requirements model, asBuilt basics). In the second step, the most suitable tender strategy in the context of BIM is determined (single-stage, two-stage, loaded, open). The current market environment must be compared with the required scope of services. The goal is to narrow down the selection to a compact array of bidders – potential contractors who are both BIM-capable and suitable for the project objective. In the third step, the tender criteria (openBIM, proof of qualification of the contractor) must be developed. The client defines the required qualitative suitability of the bidders (BIM competence, references, BIM applications) as well as the mechanisms for ensuring that this requirement is met. It must be ensured that the defined requirements allow a broad range of bidders to apply (i.e., are as low as possible) as well as guarantee reliable project implementation (i.e., are as high as possible) – and this always requires a compromise.

In the course of the tendering and awarding process, various question sessions are held with the bidders. Due to the currently still heterogeneous knowledge of BIM across the board, the bidders often submit comprehensive question catalogs, which must be answered in a competent manner by the BPL and BPS teams.

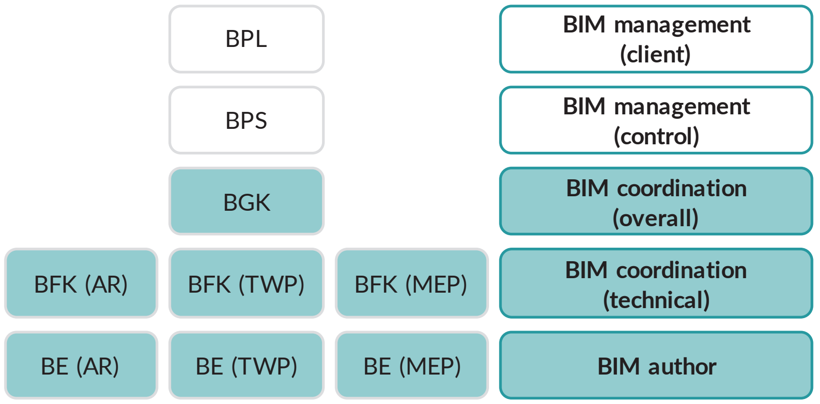
4.2.7 Conducting model-based studies/competitions

This activity is prepared by BPL and BPS in the course of project initiation and serves to find the best idea for project implementation in terms of content. BIM usually plays no or only a rudimentary role here.

4.2.8 Structure of the planning team / AN design

BPS presents and explains to the future planning contractor the entire scope of the developed basics (sets of rules, performance specifications, requirements model, asBuilt basics). This step is necessary in order to clarify all interrelationships and requirements by mutual agreement and thus to establish a uniform view of the project requirements for implementation in the entire project team.

This activity takes place in the first colloquium. At this time, the planning contractor also announces how the persons for required BIM organizational units will be selected.



Then the BEP colloquium takes place. In this meeting, the planning contractor specifies how the client's specifications are to be implemented and the steps with which they are to be implemented. The results are incorporated into the BEP. BPS moderates the development of the BEP, and the planning contractor contributes the relevant content. The negotiations for the planner contracts often take place parallel to these activities. The colloquia serve as an evaluation of the actual BIM skills. Any corrective measures in terms of qualification must be demanded at this point at the latest – or the fee can also be used to intervene.

4.2.9 Setting up the project model (PIM) by means of BIM colloquia

The specifications for model-based project execution (BEP) are evaluated in a modeling colloquium conducted by BPS. The planning contractor uses a sample model to partly implement the specifications from the BEP and elaborates relevant use cases as examples. This procedure serves to ensure the basic feasibility of the specifications on the one hand and to define relevant content for model-based collaboration within the planning team on the other. Some of the requirements are:

- ensuring that the project location/project direction is used consistently,
- ensuring the use of a uniform floor structure,
- the detailed coordination of the IFC transfer configuration in the context of the BIM software applications used to ensure the intended collaboration,
- ensuring that the team has the required knowledge for model creation/transfer (modeling and implementation of the specifications for LOG and LOI), and
- ensuring that the team has the required knowledge for model coordination/communication.

It is mandatory to complete these steps prior to planning to prevent mixing BIM setup and planning.

4.3 Planning

Life cycle phase 2.0 »Planning« (according to ÖNORM A 6241-2, Annex B) is used to develop the basic planning specifications for tendering, awarding, and construction.

The service phases of planning comprise the preliminary draft, the design, and the submission planning including the approval procedure. This section considers the content of these service phases. In general, there is no difference between the basic services and software applications within planning – only the scope of the services increases in each successive project phase due to the phase-related specifications. All requirements regarding the content to be provided and the services to be performed are to be defined by the BPS and BGK teams in the EIR or BEP rules and regulations before the start of planning and can be further differentiated in the course of the project.

This section considers the steps and definitions required at the start of planning and describes the use cases usually carried out by the BGK and BFK teams and the BIM designer (BE) in projects in the course of the work to be performed.

4.3.1 Handover of the basics to the planning contractor (asBuilt model, terrain model, requirements model)

At the beginning of the planning phases, the planners involved in the project are provided with the previously determined and generated basics. This is done via the collaboration platform (CDE). The following serve as the basis for planning:

- the terrain model,
- the inventory model (if an inventory exists and is to be used), and
- the requirements model.

The first two models are to be determined (or created) by the survey and transferred as a 3D model (see also Section 4.2.4). With their transfer, the responsibility also passes from the creator (surveying) to the planning contractor.

The representative of the owner (AG … Auftraggeber) creates the requirements model (see Section 4.2.3) and forwards it to AN planning. The authorship remains with the AG. The requirements model is integrated in the coordination model to serve, if necessary, as a reference during the planning process in order to carry out the corresponding target/actual comparison with the planning models.

All model basics are provided as IFC files. The asBuilt model, however, is provided in the native format of the BIM software application in order to ensure that further processing by the planning contractor is as loss-free as possible. However, the BIM software application of the planning contractor must be known at an early stage (at the time of model creation), which is not possible in every project, for example when conducting architectural competitions. In such competitions, a different strategy is used, in which the performance boundary between surveying and AN design is shifted. In such cases, the surveying department only provides the corresponding point cloud and AN design is responsible for the creation of the asBuilt model based on this data. The problem of the BIM software application having to be known at an early stage is eliminated. Any differences in the scope, detailing, and focus of the asBuilt model are also obsolete.

Regarding the actual implementation: at the beginning of planning, the respective BFK team must ensure that the basic models supplied can be used correctly by the other AN design team – with regard to location (georeferencing) and element definition (IFC entity). Usually, only the discipline architecture team adopts the terrain model into its authoring software. In the case of asBuilt models, it can be specified which discipline has to implement the corresponding basic information. This depends on whether the asBuilt model contains the building shell, the extended building stock, or also building services information. For example, the shell of the building can be assigned to the discipline of structural design, the developed building stock to architecture, and the building services elements to building services planning. Such a differentiated transfer of asBuilt model content must be coordinated and defined before the start of planning. This is done at the latest when the BEP is developed in the corresponding colloquium (see Sections 4.2.8 and 4.2.9).

In the course of planning, the individual domain models of the disciplines involved in the project are then created based on the basic models.

4.3.2 Structure of the model basics

The PIM (project information model) consists of the various specialized models of the respective project participants and their disciplines (see ÖNORM A 6241-2). These are also referred to as planning models.

The basic models adopted at the start of planning (terrain model, asBuilt model) remain part of the respective discipline models (see Section 4.3.1). The responsibility for establishing model-based collaboration usually lies with the discipline of architecture.

Overriding specifications can be made for all domain models used in the planning phase for planning, which facilitate their coordination and further use. In general, the BEP defines the following information for all domain models:

- the clear responsibility for a subject model and its content,
- the default for subject model naming,
- the specification of the project coordinates as well as project direction,
- the specification for floors and floor zero,
- the specification for modeling the model content, and
- the specification of the degree of elaboration of the specialized models (LOD).

These general specifications are explained below in more detail.

Clear responsibility for a subject model and its content
All disciplines involved in the project that maintain their own subject model are responsible for all content of the respective subject model. The respective BFK team is the responsible party. It ensures the qualitative composition of the provided domain model with regard to the specifications. The BFK team is the responsible contact entity for the coordinative and implementation tasks.

Different model content is to be created for each subject model:

- Subject model architecture
  - Architectural planning including
    - outdoor facilities
    - interior design
    - fire protection
    - building physics
- Specialist model structural design
  - Structurally relevant construction elements
- MEP compartment models
  (division into individual compartment models)
  - Specialist model MEP planning/heating
  - Specialist model MEP planning/ventilation
  - Specialist model MEP planning/sanitary
  - Specialist model MEP planning/electrical
  - Specialist model MEP planning/ICT planning.

Model information from project participants who do not maintain an independent domain model can be transferred to the model-managing body by means of BCF comments. This applies, for example, to fire protection and building physics data, which can be transferred to the architecture in this way. The responsibility for the content of the data remains with the supplying discipline. The receiving discipline is only responsible for the implementation of the information in the model (checks are carried out by the BFK team responsible for the model).

Default for subject model naming
Each domain model (as well as any submodels) must have a unique name. The name is constant over the entire course of the project – it does not contain any date or version information. The CDE regulates these two indicators (date of upload or versioning systems within the CDE).

In the EIR or BEP sets of rules, a specification for the naming of the subject models must be created, which
usually follows a simple coding system. Part of the coding should always be:

- the abbreviation of the project,
- the abbreviation of the author or the responsible body,
- the abbreviation of the subject model or, if applicable, of the submodel, and
- the abbreviation of the transmission configuration (see Section 4.3.3).

The naming convention should exclude the use of special characters and spaces and conform to CDE specifications.

Example of the subject model architecture:

Abbreviation for:			
Project	Author	Subject model	Transmission configuration
PRJ	ARC	FM	UK1
Result:	PRJ_ARC_FM_UK1		

Specification of project coordinates and project direction
All compartment models must be transmitted in the correct position relative to each other. For the definition of the necessary project coordinates and the project direction (deviation from geographic North), the corresponding specifications are created in the BEP before the start of planning (see Sections 4.2.8 and 4.2.9). ÖNORM A 6241-2, Annex A (normative) gives the following specification: The building model must be provided with a clear reference point, related to height in meters above the Adriatic Sea, and with a vector defining the deviation from North.

In new construction projects, the architecture domain model usually takes on the task of implementing the location information. It then rolls it out to the other disciplines in the course of the first transmission of the architecture model. In some cases, a hybrid strategy is used in which the leading architecture model is georeferenced in the higher-level measurement network (e.g., Gauss-Krüger) while spanning a local compact measurement network with the zero point on the A/1 axis defined for cooperation with the other disciplines. This allows not only a complication-free cooperation within the planning team but also an exact integration of survey results from the construction site (e.g., point clouds).

Specification for floors and floor zero point
In addition to the general definitions of the floor structure (see Sections 4.2.8 and 4.2.9), the specific floors and their designations in the BEP must be defined on a project-specific basis at the start of planning and implemented equally in all compartment models. All compartment models must have a uniform floor structure. Any deviation in the designation (including floor code), the number, or the floor height between the individual compartment models (transmitted via IFC file) is not permitted and is the responsibility of the respective BFK team. Important note: Within the native compartment models, additional floors/reference planes may be used; however, these may not be passed on.

ÖNORM A 6241-2, Annex A (normative) gives the following specification with regard to the floors of buildings: All parts of a floor must be at the same level. The distance between floors must be greater than 1.50 m (see ÖNORM EN 15221-6). The reference point of each floor (floor zero) must also be defined in the BEP.
ÖNORM A 6241-2, Annex A (normative) gives the following specification: The reference plane of the floors is linked to the top edge of the floor (excluding floor screed).

The following requirement applies mainly to new construction projects:
- The top edge of the floor (excluding floor screed) is to be used as the zero point of a floor, in accordance with ÖNORM A 6241-2.

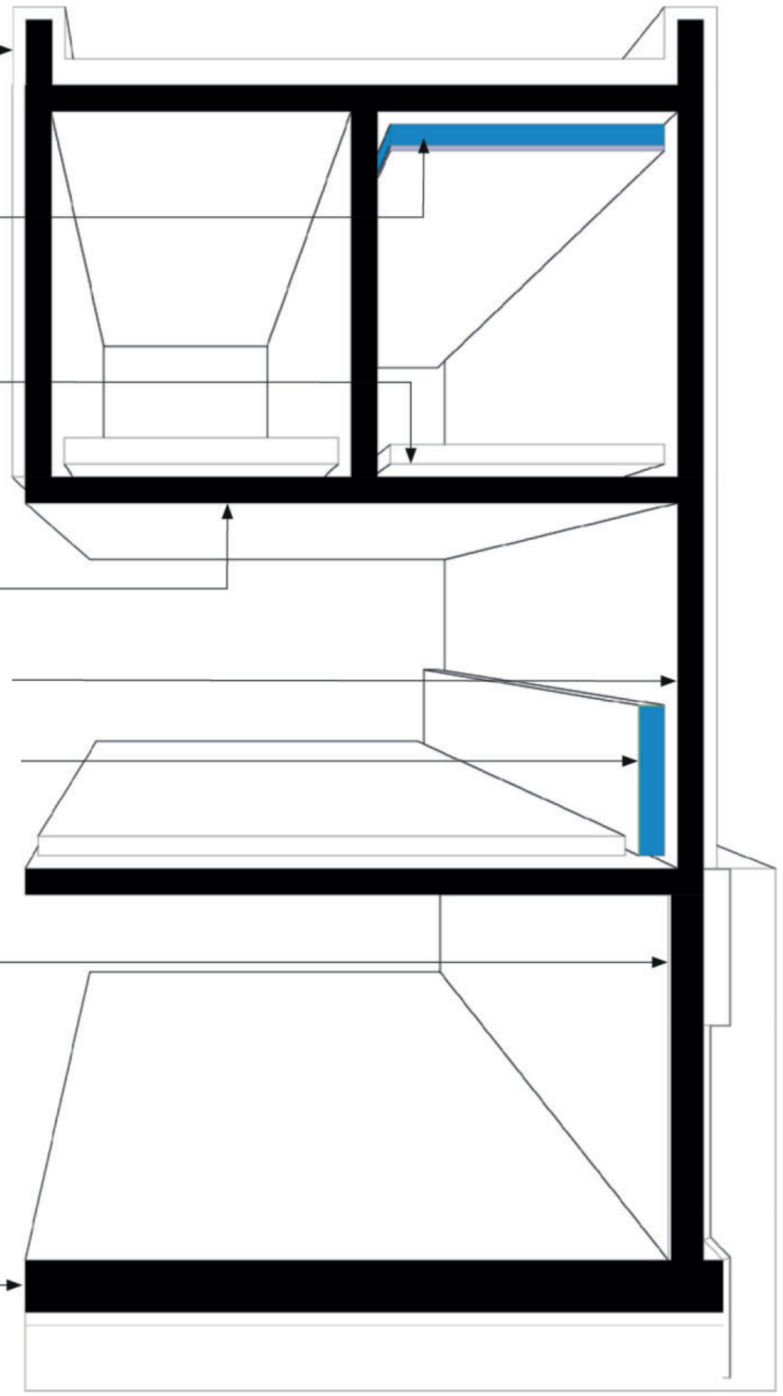
For asBuilt/conversion/renovation projects, the floor datum can be defined as follows if the top of the rough slab cannot be determined:
- The top edge of the last step of the main staircase is to be used as the zero point of a floor – this level can most likely be determined even after reconstruction.

Default for modeling the content of the model
The following basic modeling principles apply to the uniform structure of the specialized models:
- we model as it is built,
- we model only as detailed as needed,
- we model in such a way that changes can be made with as little effort as possible, and
- we model elements in structural composite systems as long as this yields benefits for the entire design team.

ÖNORM A 6241-2, Annex A (normative) further gives the following specification: All building elements are to be subordinated to the floor structure, since their construction and use is based on the accessibility for people.
It follows that
- the model elements are to be modeled floor by floor (link is to the original floor and no extension beyond).

ÖNORM A 6241-2, Annex A (normative) also provides a clear illustration for structuring the elements to be modeled. The picture on the following page is taken from the book BIM-»Leitfaden – Modell und Struktur« (Eichler), which clearly shows the elements.

Specification for the degree of elaboration of the domain models (LOD)
The development of the domain model content across the service phases is defined by the levels of detail (see Section 3.5) in the BEP. The LOD (level of development) represents the degree of development of the business models depending on the project phase and the model content according to the LOG and LOI. The table on the following page shows an example of the required level of development of the respective domain models via the LOG and LOI levels of detail to be used depending on the respective project phase (see following table).



Project phase	Preliminary draft	Draft	Submission planning	Execution planning	Handover to FM
Subject model: Architecture	LOG100 LOI100	LOG200 LOI200	LOG300 LOI300	LOG400 LOI400	LOG500 LOI500
Specialist model: Structural design	LOG100 LOI100	LOG200 LOI200	LOG300 LOI300	LOG400 LOI400	LOG500 LOI500
Specialized models: Building services	LOG100 LOI100	LOG200 LOI200	LOG300 LOI300	LOG400 LOI400	LOG500 LOI500

The formulation of the geometric (LOG) and alphanumeric (LOI) content requirements for the domain models for data exchange and further use of the model data is found in the EIR or BEP – it is created in the course of compiling the project-related requirements (see Section 4.2.1).

In the planning phases, the content of the LOG and LOI provided in accordance with the LOD are transferred to the domain models in the respective authoring software when the model content is created.

4.3.3 Establishment of cooperation

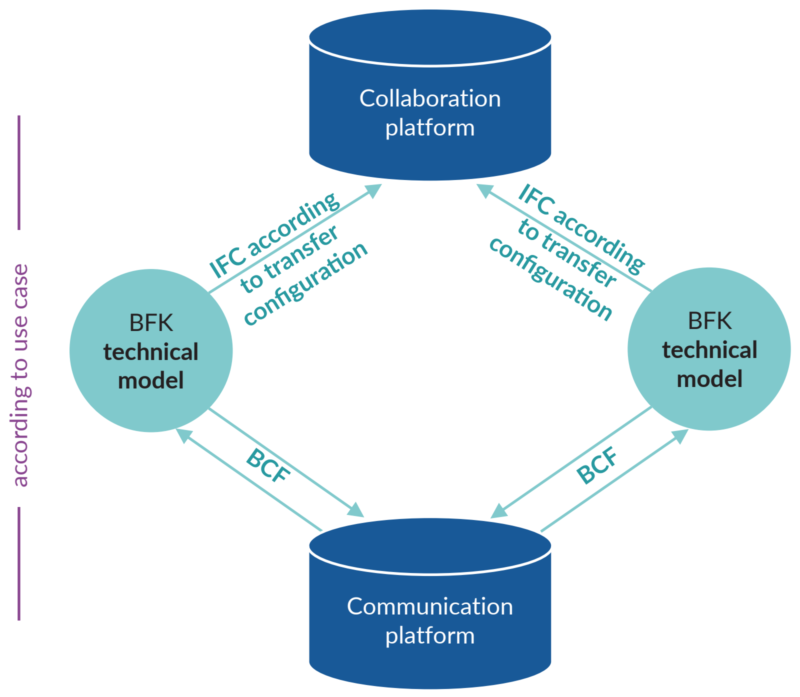
The actual model-based collaboration starts with the first transmission of domain models. The BGK team uses the subject models for the coordination of these very models. Furthermore, each discipline can add the subject models of another discipline in its own software as a reference or independently interact with the subject model data in checking software for coordination by the BFK teams.

At the beginning, the main focus is primarily on the correct location and structuring of one's own model. However, the focus quickly shifts to the actual planning content, which can be captured more quickly than in the conventional planning method (2D plans) thanks to the three-dimensionality of the model data. It should be noted here that not only comprehensive domain models released by the BGK team can be used as a reference among the disciplines, but also parts of domain models or intermediate states which can be employed selectively for reconciliation (both in the authoring software and in checking software).

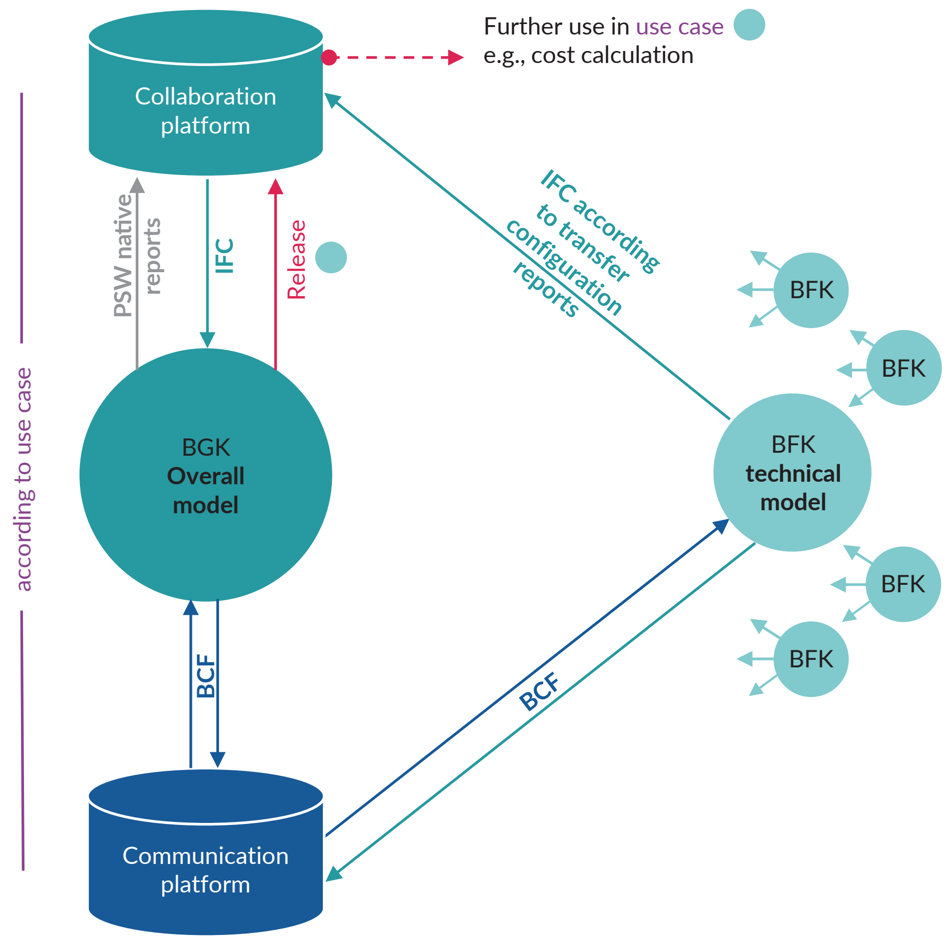
The type and scope of collaboration in the AN planning team must be defined in the BEP and described in so-called reconciliation cases:

- Big voting case:
  - Responsibility: BGK team
  - Participants: BFK and BPS teams
  - Content: Reconciliation at the end of a project phase or milestone with all business models
  - Time: Once per project phase/milestone according to schedule
- Medium tuning case:
  - Responsibility: BGK team
  - Participants: BFK and BPS teams
  - Content: Regular reconciliation
  - Timing: Ongoing predefined rotation according to schedule (= coordination meetings)
- Small voting case:
  - Responsibility and parties involved: BFK teams
  - Content: Selective/situational coordination according to a specific need; no overarching coordination by the BGK team
  - Timing: As needed, ongoing as required

Overview of small reconciliation cases:



Overview of large and medium reconciliation cases:



Regardless of the type of reconciliation case, certain basic conditions must be met and defined in advance in the BEP:

- compliance with the responsibilities, dependent on the subject model,
- compliance with the defined interfaces (IFC, BCF, DWG/DXF, PDF, XSL) (see Section 4.2.1),
- use of the specified collaboration platform (CDE) (see Section 4.2.2),
- use of the specified communication platform (for BCF) (see Section 4.2.2),
- use of the defined transmission configurations (UK), and
- compliance with the specifications from the use cases (see Section 4.3.4).

It is very important for cooperation that the required data are created or exported according to the use case (use of model data). Therefore, it is necessary to describe the corresponding transfer configuration (short: UK) in the BEP.
A transmission configuration must

- be uniquely named (abbreviation) (e.g., for use in subject model naming),
- define a unique creator,
- define a unique recipient,
- define the model type (e.g., checking model, shell model),
- be assigned to an MVD (e.g., coordination view, reference view),
- define the model content (e.g., all building elements except furniture),
- define the component setting (e.g., complete, core supporting elements only), and
- define the setting of multilayer components (e.g., composite, broken down into individual elements).

For large and medium reconciliation cases, the following further applies:

- compliance with the defined release process (see Section 4.3.5).

The transmission configurations are determined in the course of the coordination between the planners at the beginning of planning. A check run (e.g., colloquium) helps to consider the different use cases and the respective planning software with regard to the necessary export settings and to define the required content of the final transmission configuration. If further project participants are added in the course of the project phases, further necessary transfer configurations can be added.

4.3.4 Performing model management/BIM quality management

The execution of model management is a use case that takes place at different levels of responsibility and at different depths. This use case is often also referred to as BIM quality management or BIM quality assurance – and it is often understood to include the well-known collision check. However, in order to be able to map it completely, more extensive check criteria as well as the definition of a coordination plan and a data delivery plan are required.

Coordination plan and data delivery plan
A coordination plan is created for the middle coordination cases mentioned in the BEP. It describes the composition of the data to be transmitted for each project phase to permit the coordination meetings to be held (see Section 4.3.5). These data are to be provided by the respective BFK teams on the collaboration or communication platform.

According to the coordination plan the following information must be transmitted:

- IFC subject models (pre-checked by the BFK team)
  - according to the specified designation,
  - according to the specified transmission configuration,
  - according to the specified level of elaboration (LOD = LOG + LOI),
  - in the current state of work,
- BCF comments from the BFK teams (from their own preliminary review or from requests to the other BFK teams), and
- A PDF check report of the preliminary checks carried out by the BFK teams.

The data is always sent to the BGK team well before a coordination meeting. This ensures that the BGK team has enough time to carry out a quality review. The specific dates for the coordination meetings must be coordinated with and approved by the BPS.

To differentiate between the medium and large reconciliation cases, the data delivery schedule is also specified in the BEP. For data delivery in large reconciliation cases, the specifications for the data to be delivered at the end of a project phase/milestone are defined. The main difference between the data delivery plan and the coordination plan is the much higher level of checks (checking criteria) for data delivery. These are intended to ensure the actual delivery of the required model content (according to the LOD specification) (QualityGate) and are related to payment releases from the client.

For the data delivery schedule, the transmissions mentioned above for the BFK team are supplemented by:

- IFC subject models
  - released by the BGK team after the final coordination meeting,
  - according to the specified level of elaboration (LOD = LOG + LOI)
  - in the complete state of elaboration
- Plan documents in PDF and DWG/ DXF formats derived from the domain model:
  - The plans must correspond to the checked and approved status of the domain model (IFC file). 2D information that is only contained in the plan documents (e.g., dimensions) must not contradict the information in the compartment model
- Supplementary information (e.g., detailed plans)

According to the data delivery plan, the BGK team delivers

- a released coordination model (in the format of the checking software),
- a PDF check report, and
- a classification scheme of the check results (see Section 4.3.5),
  - including assignment of the check results to the passing of a necessary QualityGate.

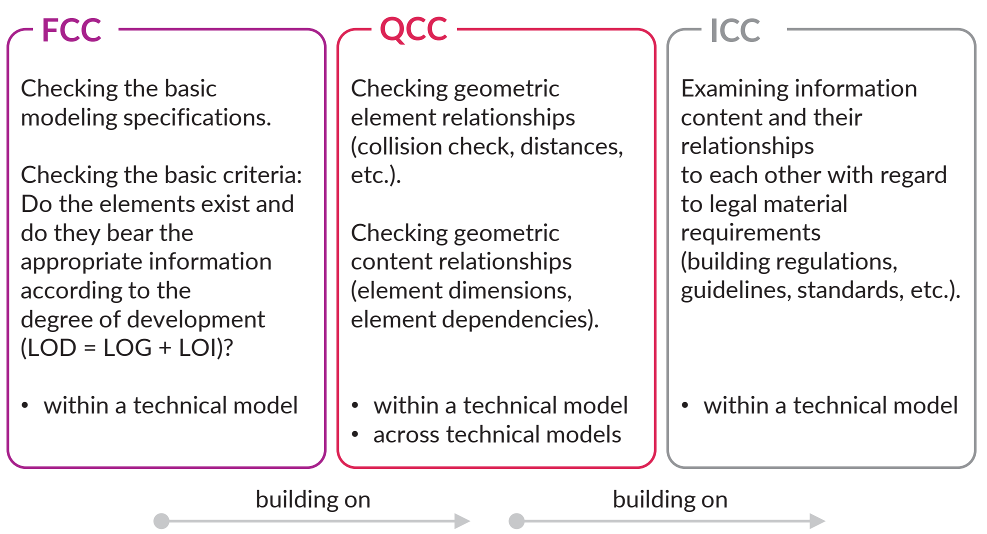
The dates for the final coordination meeting at the end of a project phase or milestone and the associated data delivery are specified by the BPS team and must be coordinated with the BGK team and the project schedule.

BIM quality management
The EIR or BEP must describe the requirements for model-based quality management or the concrete implementation for uniform quality control and coordination of the digital models. The description includes the specifications for the checking criteria that must be implemented in the checking software.

The checking criteria are classified according to different focal points, which serve to organize model checks and make the check results assessable. The system of criteria checks comprises:

- formal criteria checks (FCC),
- quality criteria checks (QCC), and
- integrity criteria checks (ICC).

This structure and its systematic content was developed by Tina Krischmann and Hannes Asmera in 2016 and can be found in many specifications for checking routines:



The FCC include:

- Basic modeling specifications:
  - elements are present and relatable to each floor and
  - GUIDs are available only once.
- Degree of elaboration:
  - LOG: Elements modeled according to LOG class, e.g., single- or multilayer and
  - LOI: Elements are correctly classified according to their IFC entity and carry the required characteristics. The value range of the characteristics is meaningful (e.g., according to a default option, contains a range of numbers, contains a true/false value).

The QCC include:

- Geometric element relations:
  - elements do not overlap (collision check) or the overlap is within the specified tolerance
- Geometric content relationships:
  - elements have a required minimum or even maximum distance:
    - e.g., minimum distance from sanitary objects to manholes,
    - e.g., maximum distance from shafts in adjacent floors.

With regard to the QCC, it should be noted that the BFK team carries out these checks internally within the domain model, while the BGK team carries them out both internally within the domain model and across domain models.
The ICC include

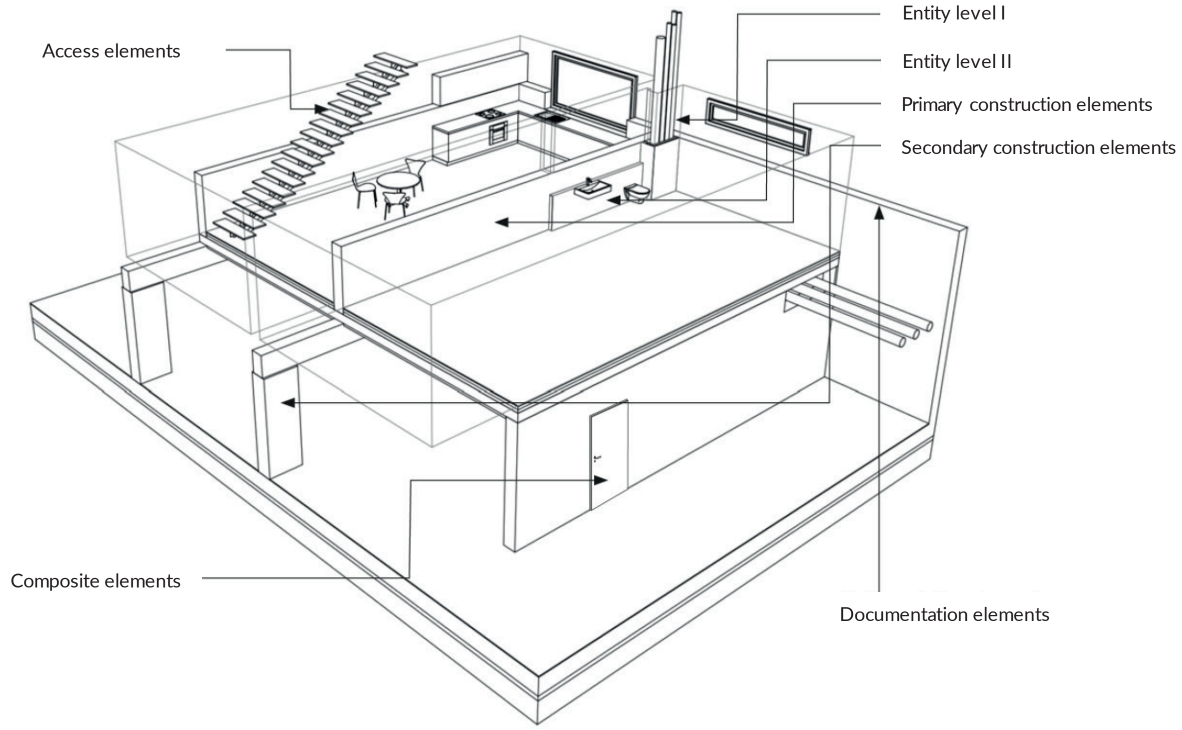
- mathematically mappable legal matter requirements,
  - e.g., escape route width and escape route length and
- relationships from legal requirements,
  - e.g., required number of barrier-free parking spaces.

Regarding the ICC, it should be noted that the local legal requirements must be strongly taken into account here. At present, only the technical building requirements can be partially mapped but not the legal building requirements (= neighboring rights). The technical building requirements can also be mapped only to a certain extent in checking software, since the technical model of the architecture does not yet carry all the necessary information and the content of the legal material further cannot be mapped mathematically in many areas. Section 4.3.10 discusses the current status and a future procedure in more detail.

All checking criteria can be supported in the checking software by filtering the available elements. ÖNORM A 6241-2, Annex A (normative) can be used for the classification into element classes. This divides the various elements logically with regard to their use. It also allows a logical check within this classification and of element classes against each other to be carried out.

This is particularly helpful for the QCC when a collision check of, for example, primary construction elements is carried out against element class I of the MEP. In this way, missing or defective openings in primary construction elements can

only be checked in a filtered manner, without having to pay attention to openings in finishing elements, which are not required in the early planning phases. The following figure shows the different element classes:



4.3.5 Conducting the coordination meetings

The results of a model check are always communicated. This is usually done in the coordination meetings defined by the coordination plan and the data delivery plan. A coordination meeting is chaired by the BGK team, and the various BFK teams and the BPS team participate. This ensures that information regarding the planning status and pending work is communicated to the planners and BIM designer (BE) (by the BFK team) and to the AG (by the BPS team).

A coordination meeting takes place directly after a BGK model check. The BGK team presents the check results within the checking software and communicates them to the responsible BFK teams. It is defined, among other things,

- by when the defects must be corrected,
- who takes primary responsibility for remediation if multiple disciplines are involved,
- which goals must be achieved by the next coordination meeting, and
- what priorities are to be set for correcting deficiencies and the upcoming reconciliation.

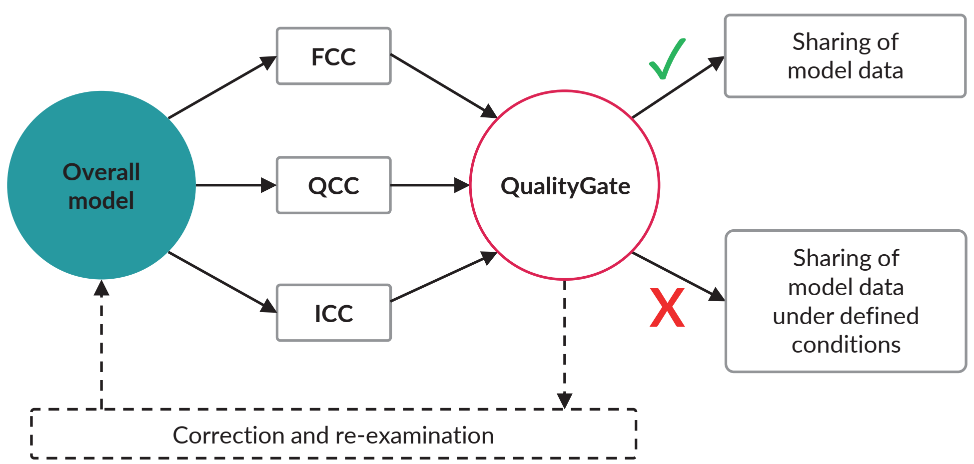
The BFK teams can also present their internal subject model check results in the coordination meeting and specify and agree on requirements for the other subject models, for example. The BGK team records the minutes of the coordination meeting and then forwards the minutes and the associated check reports to the participants via the collaboration and communication platform.

BGK and BFK check reports are composed of the individual BCFs for the defects and the associated PDF check report:

- Composition of the BCF audit report:
  The check report in BCF format contains the listing of the check results from the BIM application used for quality assurance. The elements associated with a check result must be assigned to the BCF comment based on their GUID. Any communication between project participants regarding the check result must be continued on the basis of the BCF comment in order to maintain traceability.
- Composition of the PDF check report:
  The check report in PDF format contains the listing of the check results from the BIM application used for quality assurance and an evaluation of the check results based on the defined classification scheme.

The BGK classification scheme supports the classification of the check results into the current level of development (LOD). This makes it possible to show to all participants and the AG to what extent the individual domain models and the coordinated overall model meet the requirements. A classification scheme shows the degree (percentage) to which the model data are correct – i.e., have »passed« the check. There can also be the indication »not passed« if the model data are not yet available in an appropriate format.

If the model data (as a whole or in relation to individual domain models) is not yet available in an appropriate format, the BGK team can decide whether this issue can be dealt with in the next coordination meeting or whether certain deficiencies must be rectified before continuing. This procedure applies to the middle coordination cases within a project phase.



At the end of a project phase or milestone (major reconciliation case), QualityGates are used as a benchmark for passing to the next project phase. The model data can only be passed to the next planning step if the QualityGates have been passed in full or if binding conditions have been met for the elimination of defects.

4.3.6 Performing the data transfer

The execution of a data transfer is a use case that occurs at the end of a project phase or milestone. It concerns the final planning results of a project phase that are to be transferred. These are to be provided by the respective BFK team on the collaboration and communication platform. For all data transfers, the naming and scope requirements as defined in the BEP apply.

For the transmission of the compartment models (IFC file), the following applies:

- Compliance with the specification regarding the degree of elaboration of the specialized models
- Compliance with these requirements must be ensured before the data is made available on the collaboration platform; approval is given by the BGK team:
  - All aspects to be checked must provide corresponding positive results; this is to be understood as a corresponding QualityGate.
  - A further examination of the content of the functional project objectives must be carried out separately.
  - Compliance with the specifications must be demonstrated by means of an attached check report in accordance with the specification.
- Supplementary information or in-depth information (e.g., detailed plans) are placed in the domain model by the designer by using BCF comments.
- All planning documents are derived from the respective domain model.

For the transmission of the planning documents (DWG/DXF files), the following applies:

- They must be created according to the normative specification
- Plans (DWG/DXF files) must correspond to the checked and approved status of the domain model (IFC file). 2D information that is only contained in the planning documents (e.g., dimensions) must not contradict the information in the domain model.

For the transmission of the plans (PDF file), the following applies:

- Plans (PDF file) must correspond to the checked and approved status of the domain model (IFC file). 2D information that is only contained in the planning documents (e.g., dimensions) must not contradict the information in the domain model.

For the transmission of native working models, the following applies:

- Documentation of the modeling and CAD software products used and any extensions or program add-ons and a list of all additional special elements (for domain models as IFC files and plan documents as DWG/DXF files) must be handed over.

4.3.7 Performing model-based costing

Performing model-based costing is a use case that is encountered in various project phases.

Requirements

The cost determination is carried out in evaluation software. Specialized model data are used which have previously been checked and approved by the BGK team for the purpose of quantity and mass determination:

- **Requirement: Subject model states released according to QualityGate**

Depending on the type of cooperation between the BGK team and the team performing the cost determination, different domain model data can be used. However, they are always based on the specifications of the LOG and LOI as well as the basic quantities transported in an IFC model.

- **Requirement: Plausibility check before and after the costing calculation.**

In some cases, the domain models carry the required information at different depths, so that a procedure for using the different domain model data must be agreed on – for example, the quantities and masses for the shell are determined from the domain model for structural design or from the domain model for architecture.

- **Requirement: Definition of which business model data is used for the corresponding positions.**

The requirements for the evaluation software thus include not only the ability to read and interpret IFC data correctly but also to handle multiple IFC models. The results of the quantity and mass determination are some of the things that influence the costing calculation items for a tender.

Implementation

The following specifications apply to the execution of the model-based cost determination in the evaluation software by the responsible team:

- the released compartment models (IFC file) serve as the basis for data collection,
- the identification of the model content shall be performed based on the declared Ifc classes, Ifc types, material assignments, and standard features, and
- masses and quantities must be derived from the model geometry; deviations are permitted only in consultation with the BPS team.

4.3.8 Updating the project specifications in the course of planning

The BEP set of rules is a living document. It is created at the beginning of the project, based on the specifications and requirements of project-specific EIR. However, in order to remain applicable for a project over its entire course, the BEP must be able to reflect developments in the project and constantly evolve.

As the creating role, the BGK team is responsible for updating the BEP. Changes in the BEP must always be coordinated with the BPS team in order to continue to fulfill the specifications and the requirements of the client.

Updates of the BEP can be due to

- extended requirements from the AG,
- extended requirements from the contractor,
- expanded or adapted procedures,
- expanded knowledge, and
- changing specifications at the level of
  - the project participants,
  - the interfaces,
  - the transmission configurations, and
  - the use cases.

Modifications of the BEP must also always be sent to the project-related EIR, although an update of the EIR by the BPS team is not mandatory. However, new information discovered throughout the course of the project should be examined to determine whether they should be incorporated into the project-independent corporate standard EIR so that the new findings can be taken into account in future projects. The task of continuing to develop the project-independent corporate standard EIR lies with the BPL team, which is supported by the BPS team.

4.3.9 Updating the model data

In the continuous updating of the domain models, the obligation to plan integrally and to comply with the specifications applies

- to the collaboration and communication platform,
- to the interfaces,
- to the codes and standards,
- to the authorship and responsibility of the subject model content,
- to the mandatory coordination with other subject models,
- to internal quality assurance,
- to the transmission configurations,
- to modeling, and
- to the degree of elaboration.

In the event of a change of project participants, care must be taken to transfer the planning data, including the domain model data, in such a way that the new responsible unit can take over the data without loss.

4.3.10 Carrying out the model-based approval procedures

The openBIM model as the central location of building data and information has potential for the entire life cycle of a building. However, the building submission currently plays hardly any role in the BIM project cycle. Rather, the currently required submission documentation represents an additional effort for BIM planners, since conventional 2D plans have to be generated from the models and enriched in a specified manner.

The openBIM approval process offers a wide range of advantages not only for the authorities but also for the entire construction industry. These are primarily the increased transparency in the execution of the procedure and the increased comprehensibility of the decisions. A detailed analysis reveals the following advantages:

- The elimination of time-consuming routine inspections by the building authority means that the capacities freed up can be concentrated on the more legally complex inspection points. This accelerates and improves the quality of the approval process.
- A BIM approval procedure can only be carried out by means of an open File format, which strongly promotes the use of openBIM. This in turn strengthens smaller and medium-sized planning offices, which can continue to utilize their modeling software without having to purchase new software for new projects.
- The planning offices receive an automatic basic quality check that can be carried out at any time by means of a construction engineering BIM check (even before the building application is submitted). This reduces the effort for official channels, improves the building application model (BAM) quality, and, as a result, accelerates the building application process. In practice, planning offices could also use the check for staff training purposes.
- The authority procedure exhibits greater transparency.
- The biggest advantage for the construction industry lies in the LOG and LOI requirements: The exchange information requirements (EIR) of projects and the associated LOG and LOI requirements vary widely. The openBIM approval process creates a project-independent general standard – a kind of quality seal – as the approved BIM model must meet clear LOG and LOI requirements. The building applicant and other parties (e.g., contractors for costing) can therefore better implement the BIM model in their BIM applications, since the information is already stored and checked in a standardized way.

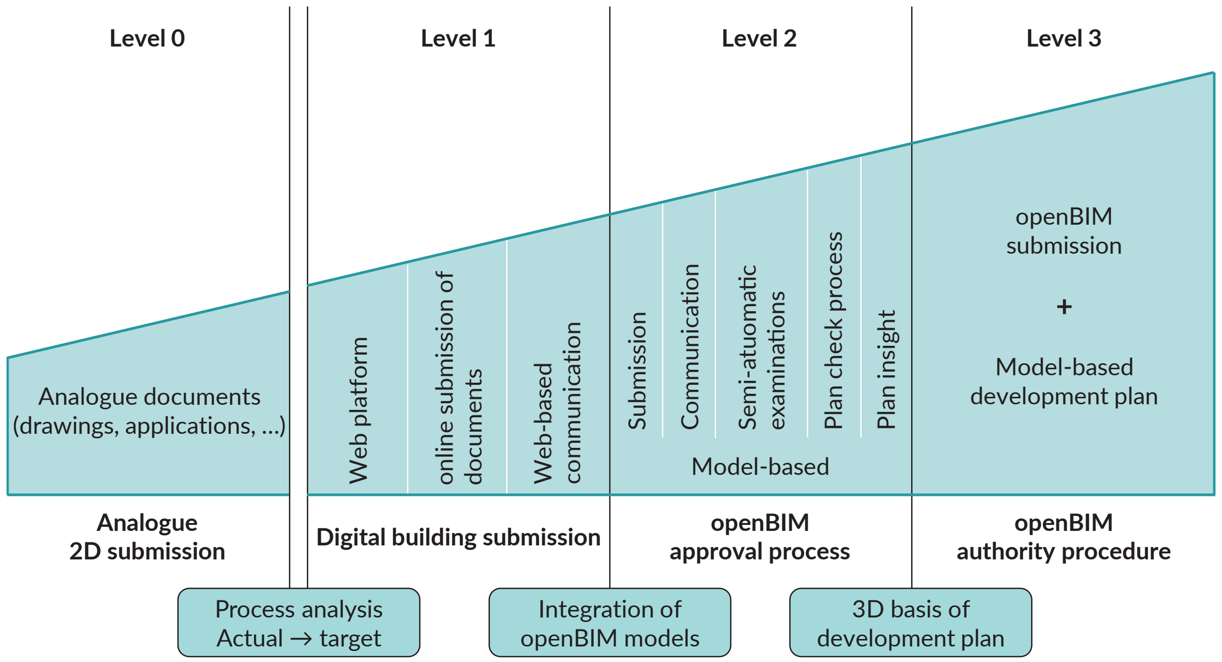
The openBIM approval process will therefore make a significant contribution to making better and more far-reaching use of the advantages of BIM and to supporting more planning offices before and during the building application process. Building authorities and administrations alike will benefit from the standards required for openBIM submissions. Thus, planning quality in BIM will improve further and BIM will be used more frequently.

Due to these advantages, more and more projects are now addressing the topic of digital transformation of the building authority or the approval process. The

Chapter 4 – BIM project implementation
4.3 Planning

city of Vienna, Austria, for example, has developed a platform for digital building submission. On this platform, building applicants/planners can access information, look for specific procedure types, and upload submission documents. However, due to legal framework conditions, a set of drawings must currently still be submitted to the authority in printed form. In the EU-funded research project BRISE-Vienna, the City of Vienna is going one step further by trying to integrate the approval process into the BIM project cycle.

Based on the research projects Digital Building Submission and BRISE-Vienna, the maturity model for approval procedures shown in the following figure was developed in accordance with ISO 19650. The maturity level of the municipalities ranges from level 0 to level 3. The current starting point for many municipalities is level 0. Submission documents are submitted in printed form and manually reviewed, entered in a digital platform and checked by the respective expert. Communication takes place via e-mail or by letter. Reaching maturity level 1 requires an as-is process analysis followed by a to-be process evaluation. This target/actual process evaluation defines the necessary technical (collaboration web platform) and legal developments. This step is crucial, as it does not make sense to only digitize existing processes without making other changes. The use of new digital tools (BIM, drones, artificial intelligence, augmented reality, etc.) in government procedures requires the rethinking of traditional processes. Therefore, it is necessary to record and analyze the as-is processes and then digitally adapt them according to the technology available. Maturity level 2 is achieved through model-based submission (building application model) and partially automated review. The legal basis (zoning plan and development plan) is still available as 2D plans. In maturity level 3, the permitted building is shown in three dimensions, which means that considerably more legal questions relating to neighboring properties can be checked automatically.



Urban, Krischmann, Schranz

4.3.11 Performing the check run of the connection of the operator's CAFM system

The establishment of operations management – especially on the basis of model-based information from BIM projects – represents a novel situation for many FM departments that requires intensive preparation. For this reason, a check run is often carried out during the course of the project to connect the CAFM system of the future operator. This takes place at the latest at the end of the design phase of the project, when fully coordinated and sufficiently detailed model content is available for the first time.

In this case, it is necessary to adjust the intended scope of the data delivery in the data delivery plan accordingly during the creation of the BEP (see Section 4.2.8). There are various specifications that are preferred, and they are usually only to be provided with the final documentation. Such specifications include tabular model evaluations which transfer model content to the CAFM system, for example. In addition, the transfer of the supplementary documentation and its link with the model content are tested.

The objective of the trial run for connecting the CAFM system is to prepare the operators and their CAFM systems at an early stage. If problems are identified during the check run, there is sufficient time to solve them. At this point, any problems with the model content or its specifications in the BEP can also be solved.

The trial run for the connection of the CAFM system is executed under the direction of the BPS team, which controls the activities of the BGK team and their respective BFK teams and at the same time maintains contact with the FM department of the operator.

4.4 Tendering and awarding

Life cycle phases 2.6 »Tendering« and 3.0 »Awarding« (in accordance with ÖNORM A 6241-2, Annex B) serve to identify and commission a contractor for the construction work (Construction contractor). This is based on the principles developed in life cycle phase 2.0 »Planning«.

Only the award procedure is handled in this life cycle phase. BIM model data can be used to support this (collection of masses and quantities, clarification of the planning intention). However, they are only a supplement to the actual core component of the tender: the bill of quantities. The following use cases describe a currently (as of 2020) common scenario of BIM-supported tendering and awarding. In this case, the planning contractor determines the masses and quantities of the majority of service items on the basis of the domain models; however, some parts of the bill of quantities are still handled conventionally because they are not included in the model (e.g., construction site equipment). In addition, the collaboration platform serves as the basis for processing the procedure, and model data is made available to the bidders for review. The project phase concludes with the commissioning of a construction contractor and a further BIM procedure that is mutually agreed in the BEP.

4.4.1 Identifying and compiling project-related requirements

In close coordination with the client, the planning contractor compiles the project-related requirements for awarding the construction contract and the correspondingly planned data transfers from the construction contractor to the planning contractor. Any company-wide, cross-project specifications serve as the basis. The result is a GU-EIR (general contractor EIR). As part of the invitation to tender, this describes the requirements for structured data transfer from the executing contractor to the planning contractor in the course of construction.

Institutional clients use the predefined company-wide AIR or EIR (across projects) as a basis. These two documents declare the general framework requirements with regard to basic uniform procedure implementation and data transfers (of product information from the construction contractor to the planning contractor in particular) across all projects.

In the first step, the planning contractor determines the most suitable strategy for the project. The project complexity/size, the assessment of the capabilities of the potential bidders, and the corresponding objectives of the client are decisive criteria. In the second step, the AN design team summarizes these requirements on a project-specific basis. Thus, they are available as the basis for the subsequent compilation of the GU-EIR.

The GU-EIR provide bidders with an overview of

- general project-related BIM processing,
- their tasks related to this, and
- the resulting responsibilities during construction.

As a result, bidders are able to precisely estimate the required effort to participate in the BIM project and include this in their bid.

4.4.2 Preparing the model basis

Now the AN planning team prepares the project-related model basis

- to provide a basis for the model-based collection of masses and quantities (support of the creation of the cost calculation / LV) and
- to be prepared as an supplement to the invitation to tender (clarification of the planning intention).

Usually, the existing BEP defines the workflows required for this as well as specifications for model export, model checking, and for determining masses and quantities. These yields checked and released domain models on the collaboration platform that comply with the corresponding specifications of the BEP.

4.4.3 Preparing the collaboration platform

The BPS team is usually responsible for the collaboration platform and therefore also prepares it. Thus, it creates the following tasks for the execution of the tender and award:

- set up any predefined processes (workflows),
- customize the appropriate authorisation structures to include bidders,
- set up user access for bidders,
- set up the components to carry out the tendering and awarding process, and
- perform a check run to evaluate the intended functionality.

The result is a collaboration platform that is set up in accordance with the corresponding specifications of the BEP for the tender processes. The range of functions required to carry out the tendering and awarding process is not always part of the collaboration platform. In recent years, various web applications have appeared on the market that focus specifically on the execution of this use case. These are referred to as AVA platforms.

4.4.4 Preparing the tender documents

In this step, the planning contractor consolidates all necessary documents. In the context of BIM-supported tendering and awarding, the following work steps are relevant:

- final determination of the masses and quantities for the most important service items from the checked and approved domain models,
- final reconciliation of the GU-EIR to describe the requirements of a structured data transfer in the course of construction from the construction contractor to the planning contractor, and
- coordination of any best bidder criteria with reference to the required capabilities for the participation of the construction contractor in the BIM project, e.g., for the structured handover of product information.

The results are finalized and coordinated documents for the tender, in accordance with the relevant specifications of the BEP. The criteria for the best bidder take into account project-related aspects as well as the current market situation.

4.4.5 Carrying out the tendering and awarding

The planning contractor carries out the tendering and awarding in close cooperation with the client in order to determine the best bidder for the execution of the construction. In the context of BIM-supported tendering and awarding, the following steps are taken:

- Announcement of the compiled invitation to tender and summoning of the intended bidders, if any.
- Bidders register their interest and get access to the collaboration platform (or the separate AVA platform).
- Bidders receive all relevant tender documents on the collaboration platform (or the separate AVA platform) – in particular:
  - the bill of quantities,
  - the relevant domain models (ideally barrier-free by means of integrated viewer functionality and a visualized link to the service specifications), and
  - the GU-EIR to describe the general project-related handling of BIM, the related tasks of the construction contractor, and his resulting responsibilities during construction.
- Bidders prepare bids within the defined time period and post the result on the collaboration platform (or the separate AVA platform).
- In close cooperation with the client, the AN design team analyzes the bids and uses them to create a price comparison list for the qualified comparison of the bidder data. This serves as a basis for preparing the negotiations.
- Conducting negotiations or renegotiations with the best bidder or other bidders. Any reworking of the bids is handled, reviewed, and analyzed via the collaboration platform (or the separate AVA platform).
- Awarding of the contract. In the event of unsuccessful negotiations, amending of the invitation to tender with amended criteria or other required services.

4.4.6 Joint development of the project strategy for the construction

Once the contract has been awarded, the BPL and BPS teams develop the project strategy for construction together with the future contractor. For this purpose, the BPL and BPS teams present the complete scope of the developed fundamentals (regulations, service specifications, GU-EIR) to the future construction contractor and explain the details. This step is necessary to mutually agree to all contexts and requirements and thus establish a uniform view of the project requirements for implementation in the future project team.

This activity takes place in the first colloquium. At this time, the construction contractor also announces how the responsible persons for data transfers or required BIM organizational units are determined.

Subsequently, the BEP colloquium takes place. In this colloquium, the construction contractor specifies how and in which steps the client's specifications (from the GU-EIR) will be implemented. The BPS team moderates this process; the associated content is received from the construction contractor. The results flow into the updated BEP.

The result of this activity is a mutually agreed procedure laid down in the BEP. This is aligned with the actual capabilities of the personnel of the Construction contractor working on the project and runs within the framework of the general specification – the predefined company-wide AIR or EIR (cross-project).

The construction contractor is able to participate in the BIM project from initial construction preparation or work and assembly planning through the entire construction to the handover of the building. The construction contractor can therefore use existing BIM information and provide the required information in a structured manner. Collaboration within the entire project team takes place without media discontinuity.

In the course of this phase, the future authorship of the domain models is also defined. If there is a change of authorship from the AN planning team to the construction team, the activities described below will become considerably more important.

4.4.7 Regulating the project model (PIM) by means of BIM colloquia

Following the BEP colloquium, a modeling colloquium will take place if the construction contractor is planning to adopt and update domain models (e.g., MEP).

This activity is carried out by the BPS team and serves to evaluate the specifications for model-based project implementation (BEP) and to ensure that the construction contractor can carry out the planned tasks for model updating in the required quality. The construction contractor must demonstrate that it can successfully handle relevant use cases and work to the specifications from the BEP on the basis of a partial model. This includes, in particular, the native transfer of the model data to the contractor's BIM software application.

It is mandatory that these steps be completed prior to the start of construction in order to prevent BIM setup and construction from becoming intermingled.

4.5 Construction

Life cycle phase 4.0 »Construction« (according to ÖNORM A 6241-2, Annex B) serves to carry out the construction of the building project by the AN construction team determined in the previous life cycle phase. This is based on the fundamentals developed in life cycle phase 2.0 »Planning«.

4.5.1 Carrying out model-based construction scheduling

The implementation of 4D BIM planning focuses mainly on the documentation of the project and serves to map the construction process that has taken place. For this purpose, the necessary properties are coordinated with the construction contractor and entered and updated in the model by the respective disciplines. This allows for the verification of the interim invoices for trades mapped in the model.

4.5.2 Carrying out the work and assembly planning

At the beginning of construction, the contractor carries out the work and assembly planning on the basis of the existing execution planning information and agrees to the use of the intended building products. Conventionally, the execution of the work and assembly planning is carried out by means of 2D-based detailed drawings which are subsequently linked to the model in order to clearly define their affiliation. The interaction with the model of the planning contractor as well as the corresponding intended responsibilities are defined in the BEP. The result is a work and assembly plan that describes in detail how the construction is to be carried out with the intended construction products by all the trades of the construction contractor.

In general, it must be ensured in advance – during the tendering and awarding process – by means of appropriately formulated restrictions in the tender documents that the framework specifications of the planning model are (essentially) not exceeded in the work and assembly planning. The fully coordinated and optimized quality of the planning model must be maintained. In the case of rescheduling, it must be ensured that this generates overall added value. In addition, the effort required to update the model must be taken into account. The determination of authorship for the specialized models is an essential aspect in the course of determining the strategy for construction. Here, mixed strategies can have a favorable effect – e.g., the architecture model remains with the planning contractor, while the building services model passes to the construction contractor. However, the effort required to transfer the model must be taken into account. Decisions to this effect must always compare the total costs with the achievable added value. Savings in construction costs that can be achieved in the short term must not cancel out savings in operation that can be achieved in the long term that were determined in the course of planning.

»Construction work planning and coordinated execution planning« as construction work and assembly planning is carried out on the basis of the following rules:

- access to the collaboration platform shall be given to the construction contractor,
- the execution and detailed design of the AN design team shall be made available on the collaboration platform,

- the detailed planning performed by the AN design team shall be linked to the respective construction elements of the digital models (by means of BCF comments or a BCF file),
- the contractor shall make the documents corresponding to the work and assembly planning in digital form available on the collaboration platform, and
- the release of the work and assembly planning information shall be carried out digitally on the collaboration platform by the planning contractor.

In addition, the following applies:
- If a revision of the digital models of the planning contractor is made necessary due to incorrect or incomplete information provided by the construction contractor, the respective expenses of the planning contractor shall be recorded (for each individual specialist planner or discipline) and deducted from the construction contractor's fee.
- All project changes, regardless of the reason for the change, are to be transmitted to the planning contractor to be inserted into the digital models after approval by the ÖBA. The changes are to be transmitted regularly, with the transmission intervals to be determined jointly by the planning contractor and the ÖBA. The changes are to be transmitted as DWG plans. All elevation data for components shall be noted in the DWG plans. The level to which the information refers (top edge, middle, bottom edge) shall also be defined.

Implementation
The following specifications apply to the execution of work planning and coordinated execution planning:
- The planning contractor provides execution and detailed planning information (consisting of digital models, plans, details) on the collaboration platform.
- On the basis of this information, the construction contractor carries out the conventional work and assembly planning (workshop and assembly plans including the corresponding execution details, selection of products, etc.) and provides the associated documents on the collaboration platform.
- The construction contractor links the detailed planning information (from work and assembly planning) on the collaboration platform with the digital models of the planning contractor by means of BCF comments or a BCF file.
- The BFK team responsible for the respective domain models compares the execution and detailed planning information with the contractor's construction and assembly planning information and identifies deviations.
- If deviations (position, dimension, specification) are identified, effects on the existing planning data must be checked by the planning contractor.

- The planning contractor coordinates with the ÖBA and the construction contractor on how to proceed with any changes. If necessary, the construction contractor modifies the work and assembly planning documents.
- The BFK team responsible for the respective domain model checks the documents provided for the contractor's construction and assembly planning and approves them.

Result
The following results are to be produced in the course of the work planning and coordinated execution planning:
- approved work and assembly planning of the construction contractor, which has been integrated in the execution and detailed planning of the planning contractor,
- approved work and assembly planning of the construction contractor, which can be used as the basis for construction,
- all documents of the contractor‘s construction and assembly planning are available in digital form on the collaboration platform, and
- the detailed planning of the Contractor Construction is linked to the respective construction elements in the digital models of the planning contractor by means of BCF.

4.5.3 Carrying out the asBuilt documentation during construction
The surveyors and the authors responsible for the specialized models carry out the asBuilt documentation during construction. In this way, they ensure that the construction conforms to the planning specification (at the level of work and assembly planning). Laser scanners are used to record the respective stages of construction. The resulting point clouds are compared with the domain models using automation. Any deviations can be identified and coordinated and the result can be documented in the model. The relevant specifications for implementation and the associated responsibilities are defined in the BEP. The result is the complete documentation of the asBuilt status in the form of updated domain models.

Requirements
Model-based asBuilt documentation is performed according to the following rules:
- Access to the collaboration platform must be granted to the surveying team.
- The surveying team will receive training on the use of the collaboration platform as needed.
- The business models represent the data basis (target state).
- The recording of the building condition (actual condition) is to be carried out by qualified personnel of the surveying team description by means of laser scanners according to the following description.
- ÖBA reports completion dates to the surveying team in a timely manner.
- The contractor shall ensure the basic visual accessibility of the completed services on the completion date.

- The recording of the construction condition (actual condition) is carried out in the following phases of construction. The exact times of the execution are to be determined by the ÖBA in cooperation with the construction contractor:
  - Completion of shell (floor by floor)
  - Completion of MEP / collecting lines (basement)
  - Completion of finishing / dry wall construction (floor-by-floor, single-sided planked walls)
  - Completion of MEP-V (floor by floor, main lines / central offices / distributors)
  - Completion of MEP-E / I (floor by floor, main lines / central offices / distributors)
  - Completion of MEP-S (floor by floor, main lines / central offices / distributors)
  - Completion of building and exterior (as a whole)
- Provision of the results of the survey to general planner (GP) and ÖBA is to be carried out via the collaboration platform.

Implementation
The following guidelines apply to the implementation of asBuilt documentation:
- The construction contractor notifies the ÖBA of upcoming completion dates.
- The contractor shall coordinate the dates for the recording of the construction status (actual status) with the ÖBA.
- ÖBA reports the surveying dates for the recording of the condition of the construction (actual condition).
- The contractor prepares the completed section (floor by floor) for the recording time slot and ensures visual accessibility (e.g., material storage, scaffolding, etc.).
- The surveying team performs the recording of the state of construction (actual state) on the scheduled date.
- The surveying team reports completion of the recording of the construction condition (actual condition) to the construction contractor and the ÖBA.
- The surveying team provides the results to the BGK team.
- The BGK team compares the point cloud (actual condition) with digital models (target condition) and if necessary identifies deviations of positions and dimensions beyond the contractually specified construction tolerance (according to the bill of quantities).
- In case of deviations, the ÖBA will be notified.
- The ÖBA in coordination with the AG decide between the following two options:
  - adjustment of the deviations by the construction contractor (deconstruction or new construction) or
  - prompt adjustment of the execution and detailed planning (consisting of digital models, plans, if necessary also details) by the responsible author of the respective specialized model at the expense of the author.

Result
The following results are to be produced in the course of the creation of the as-Built documentation:
- documentation of the respective phases of construction by means of the survey data (according to the specification inventory) and
- documentation of the state of construction by means of updates to the execution and detailed design (consisting of specialized models, plans, associated final details).

4.5.4 Performing model-based product documentation
The construction contractor prepares the model-based product documentation in which the products installed are documented for commissioning and subsequent operational management. The domain models updated in the course of the creation of the asBuilt documentation serve as the basis. Based on these models, construction product specifications are collected and randomly checked for compliance with the built construction. For the product specifications thus evaluated in the model, the construction contractor enters the required product features for operational management (LOI500 for maintenance, checking, warranty, etc.) in the model and collects the associated documents (technical approvals, instructions, etc.) in a structured manner. These documents are stored in a structured manner on the collaboration platform and linked to the model. The relevant specifications for implementation and the associated responsibilities are defined in the BEP.

The result is a complete product documentation of the asBuilt state contained in the updated compartment models (LOI500) as well as the linked documents.

Implementation
The following guidelines apply to the implementation of the final documentation:
- The BPS team provides templates (which may not be changed structurally by the AN construction contractor) for the transmission of product information (tables according to ÖNORM A 7010-6, Annex B). The content of the product information tables refers to elements (and their unique number: GUID) from the domain models.
- The contractor shall provide the product proposal (based on the planner's template) in the course of work and assembly planning.
- The client / planning contractor / the ÖBA check equivalence and issue product proposal for approval if necessary.
- The contractor shall send product information in a structured form (based on templates for the transmission of product information provided by the BPS team) to the planning contractor (as an Excel spreadsheet or via a database interface).
- The ÖBA verifies products in the completed structure on a selective basis and issues approval if necessary.
- The respective responsible author transfers the product information to her/his subject model.

Result
The following results are to be produced in the course of product documentation:

- domain models updated to LOI500 (with details of maintenance, checking, warranty, etc.) and
- storage of the associated documents (technical approvals, instructions, etc.) collected in a structured manner and linked to the model.

4.5.5 Compiling and handing over of construction documentation

This activity is carried out by the responsible authors of the domain models as soon as construction is complete and serves to check and merge the steps executed during the creation of the asBuilt documentation and product documentation carried out in the previous activities. The relevant specifications for the implementation and the associated responsibilities are defined in the BEP.

The result is complete, verified documentation of the asBuilt structure contained in the updated specialized models and technical documentation, suitable for handover to management.

The following applies: The handover of the final documentation for the construction handover must be complete and free of errors.

The following applies when the associated domain models (IFC file) are provided:

- The specification regarding the degree of elaboration of the specialized models must be complied with.
- The complete and error-free compliance with the specifications regarding the degree of elaboration of the domain models must be proven by means of a check report.
- All plan documents provided in addition to the model shall be derived from the respective subject models.
- All supplementary information or more detailed information (e.g., detailed plans) is placed in the domain model by the designer using BCF comments.
- The following information is to be handed over:
  - summary file directory,
  - documentation of the modeling and CAD software products used, any extensions or program add-ons, and a list of all additional special elements (it must be possible to reproduce the working environment),
  - the domain model architecture (native and as an IFC file) with all domain models as an IFC reference,
  - the remaining domain models (native and as an IFC file),
  - the last valid positive check reports (as PDF and BCF files),
  - the room and plant book (as an XLS file),
  - the SAP component list for all care/maintenance/inspection-relevant equipment (as an XLS file) as well as
  - the asBuilt documentation with point cloud (E57 file) and panoramic images (TIFF files).

Result
The following results are to be produced in the course of the creation of the final documentation:

- A documentation of the construction condition by means of updated execution and detail planning information (consisting of digital models, plans, details) including all relevant product information according to ÖNORM A 7010-6, Annex B.

The client receives a complete documentation of the structure. Based on this, the future operator can link its technical and commercial management in accordance with ÖNORM A 7010-6.

5 Appendix – A planning game – a useful simulation tool in the context of BIMcert training

Author: Hannes Asmera (ODE office for digital engineering)

This guest article was written by Hannes Asmera as an exposé for the exam to become a certified trainer at buildingSMART Austria. The article describes a simulation game that is very well suited for the BIM collaboration workshop of the BIMcert training (BIM coordination and BIM management).

Introduction

The planning game is an action-oriented teaching and learning method. As part of the BIMcert training, it is used as an informal instrument to apply and deepen the previously taught theories of the various areas of BIM in a setting that is as close to reality as possible.

The goal is the BIM-based interdisciplinary implementation of a planning task, whereby the focus is not on planning performance in the authoring software, for example, but on the preparation and implementation of the planning processes as well as on the development of the communication skills of all participants.

The following is a brief explanation of the theoretical background and the conceptual structure with the individual roles and tasks of the role play within the framework of BIMcert training. In addition, the actual implementation with all individual steps is clearly outlined and a conclusion is drawn.

5.1 Theoretical background

The planning game represents a form of group work and is characterized by the fact that the participants communicate with each other and learn together.

More specifically, a planning game is a simultaneous and holistic teaching and learning method designed to promote the planning and decision-making behavior of course participants.

Through a planning game, participants are prompted to analyze complex tasks in a group setting, develop proposed solutions, and make decisions in a limited amount of time. Thus, the method facilitates an interactive, interdisciplinary, and dynamic solution of complex problems, and the strengths of the individual are used for the benefit of all group members.

The basis for the simulation carried out in the BIMcert training is the newly acquired knowledge of the previous modules with the aim of simulating and deepening this theoretical knowledge under guidance, using a fictitious project with all its roles and challenges. In addition, the participants' communication behavior and conflict management can be observed and subsequently reflected upon.

The following phases are distinguished in a planning game:

1) Preparation
2) Allocation of roles and tasks

3) Repetition of the phases
   - Problem analysis
   - Solution search and decision planning
   - Resolution
   - Action implementation
   - Feedback collection
4) Follow-up

The time frame for this detailed form of group work is two course days of eight hours each, including breaks.

5.2 Content and organization of the planning game

This section explains the content available and the content to be generated as well as the organization of the simulation.

5.2.1 Preparation

There are two basic technical requirements or existing bases. On the one hand, the shell of the architectural model is provided as an IFC file and in a native file format. On the other hand, the EIR of buildingSMART Austria apply, as explained in the preceding modules. This starting point is chosen in order to quickly get to the interdisciplinary work of the groups.

On the software side, Solibri is specified as the checking tool. The use of the authoring software depends on the competence of the participants; however, any software used must be buildingSMART-certified. The competences of the participants and the software to be used will be determined in advance in order to ensure a high-quality simulation and to optimally prepare the division of the groups.

A common data environment (CDE) in the broadest sense is specified as a platform that must, at a minimum, allow a coordinated file exchange (e.g., Nextcloud). In this platform, the fundamentals, the EIR, and the shell of the architectural model are available as an IFC file and in a native file format. The additionally required folder structure must provide at least one item for each role. The read and write rights for the roles, which are limited to the relevant group of participants, must be taken into account here. In addition, transfer folders are required for the three voting cases (small, medium, and large), with corresponding write rights for the participants.

In addition to being used for file exchange, platforms such as BIMCollab Cloud can also be used as part of the simulation. A real CDE platform such as Aconex or ThinkProject is too complex and cost-intensive for the objective and scope of the simulation.

5.2.2 Distribution of roles

Certain roles are assigned to the participants and the planning game management. The individual roles for the simulation are those of the major planning participants present in practice and thus represent only a part of the real planning participants.

The group sizes depend on the number of participants. Ideally, the group should have between three and five people. The simulation should be conducted in two parallel groups if the number of participants requires it.

Client (AG):
The scenario for the AG is the planning of an office building with a possible extension of the premises on the other side of the street. At present, however, the client is still unclear about how to proceed. This role is taken over by the planning management.

BIM project management (BPL):
The BIM project management is responsible for the general specification of the framework conditions of a project as required by the client. This includes the service specifications used by the respective players and the data structure used in the project. The results of this task result in the EIR which are specified here. In the context of the simulation, it may make sense or be necessary for the AG and BPL to merge into one role and for the role to be performed by the simulation management.

BIM project management (BPS):
The BIM project management team represents the BIM interests of the client in BIM specification and operational implementation of the BIM project based on the specifications of the BPL team.

These specifications are essentially the EIR, on the basis of which the BEP is created. This is communicated to the BGK team and, if necessary, adapted and updated for specific projects.

BIM overall coordination (BIM-Gesamtkoordination BGK):
The BIM overall coordination team agrees and verifies BIM content of the planning participants based on the specifications of the BIM project control team for all disciplines. The coordination model as well as the monitoring of compliance with the BIM rules and regulations on the part of the specialist planning team is their responsibility. The BIM overall coordination is the link between BIM project management and the planning team.

BIM specialist/technical coordination (BFK):
The BIM specialist coordination team coordinates the BIM content of the respective specialist discipline on the basis of the specifications of the overall BIM coordination team of the project. This role is further split into three roles:
- BIM technical coordination architecture (ARC)
- BIM specialist coordination structural design (TWP)
- BIM coordination of technical building equipment (HVAC)

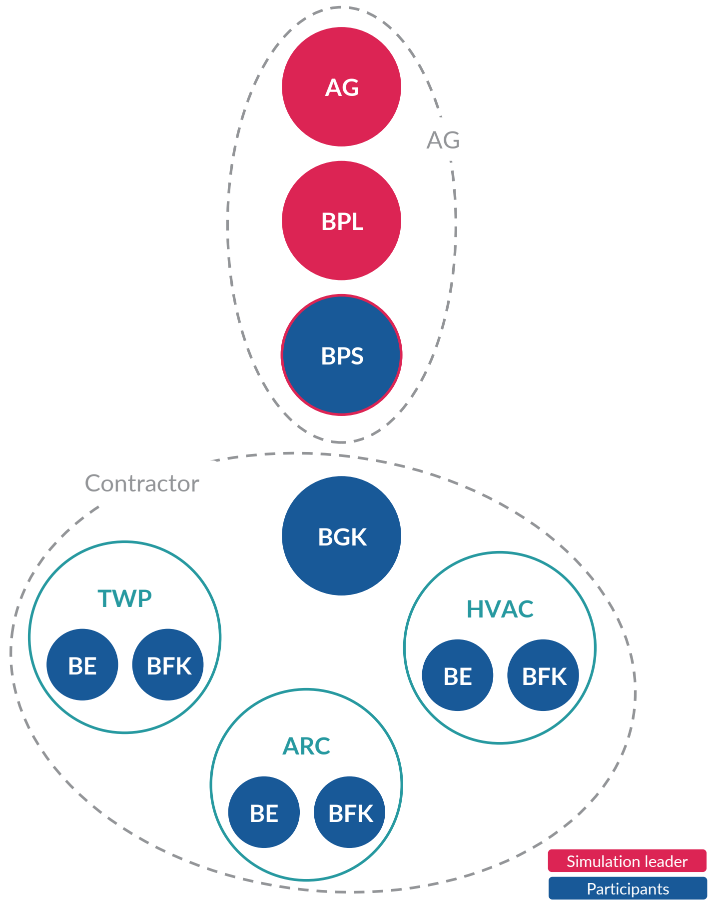
BIM designer (BIM Ersteller BE):
The BIM designer creates the BIM content in the respective discipline.

5.2.3 Organization
In the following paragraphs, the detailed organization including task definition is described.

Explanation of the task in the planning game
At the beginning, the basic framework and the tasks are explained. This is an interactive group activity with the goal to reach defined milestones within the given time.

All participants are part of the project team. Then, a distinction is made between subgroups. The division into groups is carried out by the planning team, whereby the aim here is to form heterogeneous groups. This creates a very good opportunity to look at a project from a perspective different to the participants' familiar working environment. It should be ensured, however, that there are sufficient participants available in each group with the required specialist knowledge (e.g., architects with corresponding software knowledge in the architecture group).

The graphic shows the organization of the participating groups and their tasks:



Tasks of the AG and the BPL team
For didactic and organizational reasons, the role of BPL is generally taken by the simulation leader. However, if the total duration and group size of the simulation were to be increased, it would be possible to have participants take over the role of BPL as well.

The main task of the simulation management is to support all groups with regard to technical, planning, and organizational details, and it is thus responsible for the supervision or accompaniment throughout the entire simulation to ensure that the objectives are achieved.

The focus is on the process-oriented factors of the project and not on the detailed planning performance. The goal is to conceptualize the metadata of a project and check it with a critical eye for initial feasibility.

Tasks of the BPS team
In cooperation with the BPL, the BIM project management team must develop a reduced-scope project-specific BEP on the basis of the EIR issued by buildingSMART Austria. This is to be communicated to the BGK team. In addition, the CDE platform must be prepared for use in the project.

The BPS team also represents the interface between the project participants on the AG's side.

Tasks of the BGK team
The BGK team is the interface between the contractor and the client. Before the BEP is transmitted, it must prepare the project participants organizationally (as far as possible) and set up the Solibri checking system. The BEP specified by the BPL team and any updates must also be coordinated. In addition, an overall coordination review must be carried out and subsequently an overall coordination meeting must be held and documented in a report.

Architecture tasks
After the group has transferred the provided model into its native software, a standard floor (preferably the first floor) is to be further detailed for office use. Likewise, a facade is to be planned.

At defined and appropriate points in time, but at least at the milestones defined by the BPS team, the architectural model shall be provided by TWP to the MEP teams who need to agree on its content as a reference for their planning.
In addition to the creation of the domain model, an internal schedule matching the BEP of the BPS team must also be developed, the LOI of the BEP must be implemented, and the specialist coordination must be prepared and carried out.

Tasks of the technical building equipment team
On the basis of the building shell provided as an IFC file, functional diagrams and the first central supply lines can be planned. As soon as a more detailed architecture model is available, the MEP is to be extended to the detailed floor.

In addition to the creation of the domain model, an internal schedule must also be developed to match the BEP of the BPS team, the LOI of the BEP must be implemented, and the specialist coordination must be prepared and carried out. This is based on the milestones defined by the BPS team.

Tasks of the structural design team
To carry out the structural design, a separate model based on the shell structure (provided as an IFC file) can be created or transferred to the native software. As soon as the more detailed architecture model has been transferred, the models must be compared and, if necessary, corrections must be made to the calculation of the LOI.
In addition to the creation of the domain model, an internal schedule must also be developed to match the BEP of the BPS team, the LOI of the BEP must be implemented, and the specialist coordination must be prepared and carried out. This is oriented toward the milestones of the BPS.

5.3 Presentation of an implementation example

In the following sections, the implementation (including schedule) of the simulation game within the BIMcert training is outlined in detail.

5.3.1 Project start

After all roles and tasks of the respective planning participants have been communicated, the actual project start takes place.

5.3.2 Green table

The kickoff of the project with all project participants takes place at the »green table«. The AG communicates its requirements for the project, the rough time frame, and the basics. The BPL team provides the EIR for this.

Subsequently, the first internal coordination must take place. This takes place on two levels. In the first step, the groups internally agree on their structure and rights and obligations, and then this process takes place across the groups.

During this phase, care should be taken to ensure that the following points are taken into account on the part of the participants:

- Milestones and project schedule
  The participants are aware of the rough time frame and the required deliverables. Based on this, a realistic schedule for the implementation of the individual tasks as well as the milestones in the project schedule are to be defined. Here, the schedules of the individual disciplines are created and coordinated with each other.
- Definition of responsibilities
  The responsibilities within the tasks are to be defined. In the disciplines of architecture, structural design, and building services engineering at least the following roles and associated knowledge are required:
  - BIM specialist coordinator in a leading role and as contact person for the BGK team,
  - examiner with knowledge in Solibri (and knowledge in rule creation), and
  - modeler with expertise in the respective software (and in IFC export and import).

In the area of overall BIM coordination:
- overall BIM coordinator in a leading role and as contact person for the BFK and BPS teams and
- auditor with knowledge in Solibri (and in rule creation).

In the field of BIM project control:
- BPS contact person for coordination with the BPL and BGK teams and
- BEP responsible persons with focus on LOI200 and LOG200, transmission configurations, and project schedule.

- Test control sets
  The handling of the checking rule sets must be explained. Basically, there are two procedures here. Either the BPS team and the AG provide the checking rule sets for the BGK and BFK teams or the individual groups have to work them out independently for the BGK and BFK teams. Depending on the size of the group and the time available, either option can be chosen. This choice can be made by the AG or by internal coordination of the participants.
  The following classification of rule sets is mandatory:
  - FCC (formal criteria check):
    These are so-called basic criteria. They mainly include checks for the existence of information and geometries and their logic and basic order, for example whether rooms exist and are subdivided into valid room usage types.
  - QCC (quality criteria check):
    Here, checking criteria are based on the correctness of the FCC. They mainly include the checking of geometric relationships (collision check, distances, etc.) as well as content relationships (element dimensions, element dependencies, etc.), for example whether a room actually has the necessary room height (= information) without collisions (= geometry).

5.3.3 BIM management/project control
The first task for the BPS team is to create a BEP based on the EIR available from buildingSMART. The minimum requirements are:
- the definitions of LOI200 and LOG200 and the element classes to be mapped in this form must be provided (see tables below),
- a sufficiently detailed project schedule for planning up to the first overall coordination meeting, including milestones, must be prepared, and
- the transmission configurations must be defined.

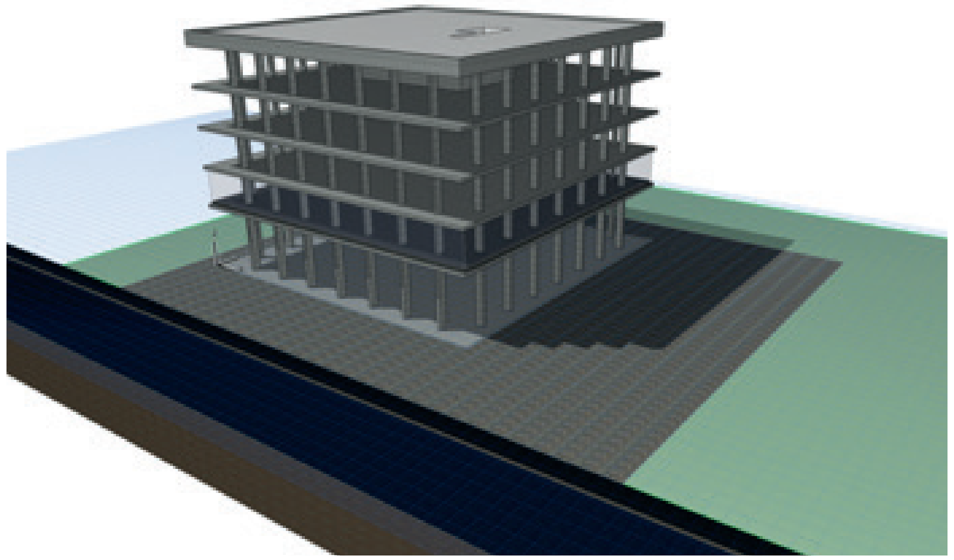
Other desirable details that a BEP should contain include the project organization and the use cases in quality management.

It is important that the BEP be prepared as accurate and quickly as possible and sent to the BGK team. The BEP must be presented to the BGK team, which must agree to it. The first version of the BEP is then released for use in the project. Updates, corrections, or refinements as well as the monitoring of the project progress must be defined in the BEP.

5.3.4 Overall BIM coordination
The organization of the project as well as the checking of the rule system can take place before the BEP has been submitted. The milestone is the date for the release of the first version of the BEP. As soon as this is available from the BPS, it must be checked for contractor interests and possibly adapted in coordination with the BPS team.

The first fully valid version of the BEP is now communicated to the planners so that they can incorporate the requirements into their planning. The BEP-compliant checking rule development must be commenced, and the partial models for the overall coordination test must be handed over on time. In the meantime, the BGK team has to coordinate the update of the BEP, ensure that the project progresses, and report the project progress to the BPS team.

5.3.5 Modeling architecture
The architecture team builds on the shell model provided (see example in the following image) and develops this model further by focusing on a control floor. In parallel, the inspection rules must be developed in Solibri for the BFK team. The check reports developed by the BIM technical coordination team have to be communicated using BCF files.



5.3.6 Modeling technical building equipment
On the basis of the shell model provided, the development of the building services model is started. The first functional diagrams and central supply lines can be planned. As soon as the more detailed model has been submitted by the architecture department the building services must also be expanded and detailed accordingly.

For this purpose, the checking rules must be created in Solibri for the BIM technical coordination team and subsequently applied to the model. The check reports have to be communicated using BCF files.

5.3.7 Modeling the structural design

Here, a separate structural design model is developed based on the shell model provided in order to be able to perform calculations easily. As soon as the more detailed model has been submitted by the architecture team, the structural model must also be expanded and detailed accordingly.

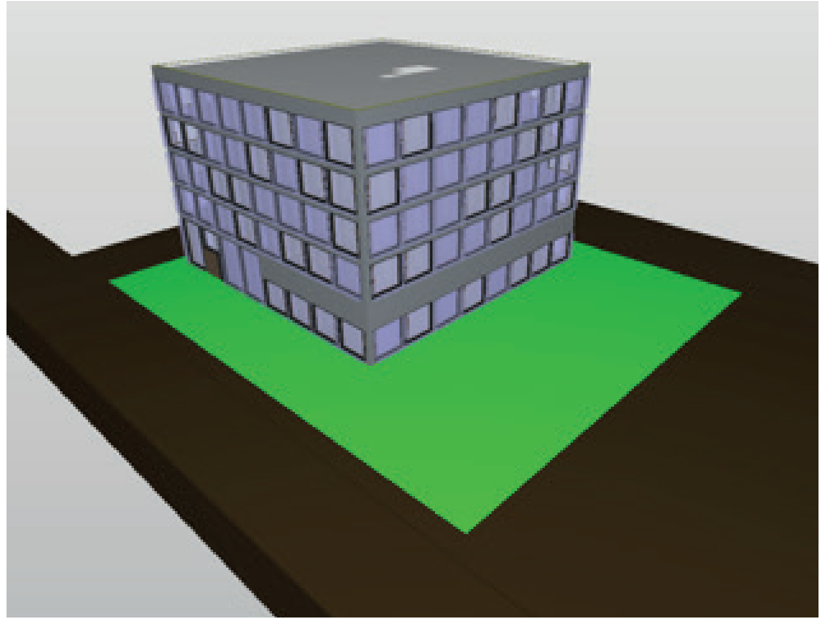
Likewise, the rules required in Solibri for the BFK team must be developed. The audit reports of the BFK team have to be communicated using BCF files.

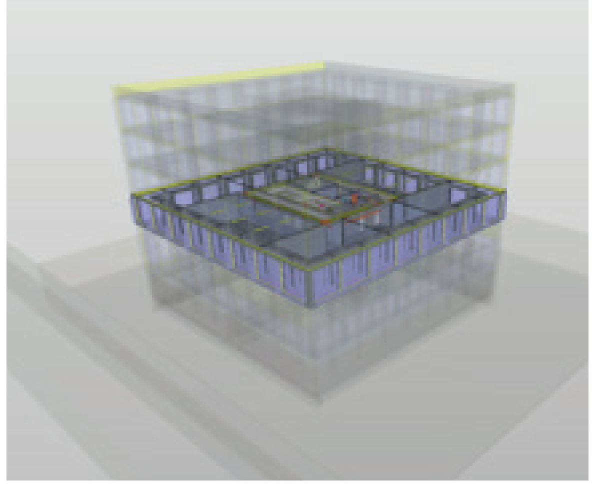
5.3.8 Overall coordination check

Here, all subject models are imported into Solibri and assigned to the respective disciplines. The first step is a visual inspection of the models. The focus is on

- the common origin or the correct location,
- the apparent completeness of the models,
- the use of IFC classes corresponding to the intended use (random sampling), and
- the existence of corresponding property sets.

Subsequently, the application of the created FCC and QCC rules takes place as specified in the BEP. When documenting the problems found, a title, description, responsible person or discipline, prioritisation, and due date for correction must be recorded. The check results are summarized in a check report.
The following images show a complete model:

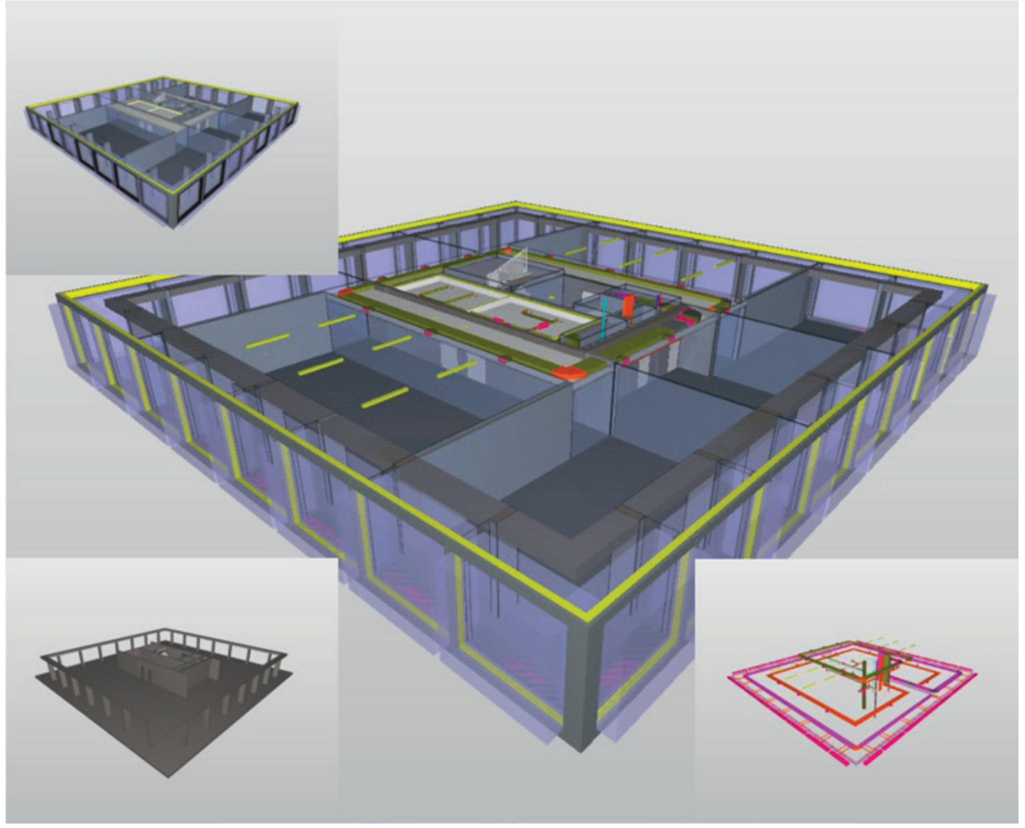




5.3.9 Overall coordination meeting

In the overall coordination meeting, the BGK team presents the problems found or issues to be discussed in the presence of the BPS team. Each aspect is discussed individually and, if necessary, the title, description, responsible person or discipline, prioritisation, or due date for correction is adjusted. It is important that the meeting is well managed and that the parties involved communicate with each other. The review report is attached to the minutes, which are issued in BCF format to all project stakeholders for further action.

The following image shows an overall model in detail:



5.3.10 Summary

Here, the planning of the project ends and a summary is created. At the beginning, the simulation leader gives the participants feedback on the achievement of the objectives with regard to the requirements of the AG. Afterwards, the possible further development of the participants are discussed.

The participants should also reflect on successes and difficulties. If necessary, the planning game leader moderates this feedback round.

5.4 Conclusion

The implementation of a planning game in the form shown has many advantages. The learning impact is usually higher, since the duration of occupation with the learning object is usually more intense. Important are the chronological sequence and the shortest possible distance between the learning content and the planning game. In addition, the practical application of the theory results in the deepest possible understanding of the subject matter. In addition, it helps to strengthen the group and increases networking.

The disadvantages are the increased time required and the intensive preparation, follow-up, and support needed during the simulation. In addition, the group leader must have a high degree of professional and pedagogical competence and also act in the role of a consultant. Therefore, a great deal is demanded by the persons involved during the planning and implementation of the simulation.

In summary, the planning game aids the acquisition of problem-solving competencies, assessment skills, entrepreneurial thinking and action as well as the implementation of knowledge and the holistic experience of BIM contexts, which also facilitates the subsequent transfer to everyday work. For these reasons, the planning game presented is justifiably an essential component of successful and sustainable BIMcert training.

With the “Professional Certification« programme” (“Foundation” and “Practitioner”), buildingSMART offers an internationally comparable quality standard for the certification of openBIM knowledge. BIMcert provides the training developed in Austria for this certification. The “Practitioner” certification in Austria is divided into BIM Coordination (in Austria until 2021: Level B) and BIM Management (in Austria until 2021: Level C).
This book is dedicated to the functional training of openBIM and describes all subject areas for these certification levels. It starts with an overview of digitalisation basics and the most important terms of openBIM. This forms the basis for the “Foundation” certification (in Austria until 2021: Level A). Those interested in theory as well as BIM practitioners will then receive a compact and in-depth insight of IFC, MVD, IDM, BCF, CDE, LOD, and BIM standardisation. Armed with this knowledge, BIM practitioners will find the necessary functional knowledge in the chapter “BIM project implementation” in order to then be certified at BIMcert Level B and Level C (Practitioner BIM Coordination und BIM Management, respectively).

MIRONDE

ISBN 978-3-96063-044-9

9 783960 630449