CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

Department of Construction Management and Economics

MASTER THESIS

2019

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ZADÁNÍ DIPLOMOVÉ PRÁCE

I. OSOBNÍ A STUDIJNÍ ÚDAJE

Příjmení: **Galitskaya** Jméno: **Irina** Osobní číslo: **412567**

Fakulta/ústav: **Fakulta stavební**

Zadávající katedra/ústav: **Katedra ekonomiky a řízení stavebnictví**

Studijní program: **Stavební inženýrství**

Studijní obor: **Projektový management a inženýring**

II. ÚDAJE K DIPLOMOVÉ PRÁCI

Název diplomové práce:

Zadávání zakázek metodou informačního modelování staveb (BIM) pro pozemní stavby

Název diplomové práce anglicky:

Procurement utilizing building information modeling in civil construction

Pokyny pro vypracování:

Práce se bude věnovat popisu použití metody informačního modelování staveb (BIM). Bude provedena rešerše zahraničních zdrojů týkající se oblasti užití BIM a zadávání zakázek pro pozemní stavitelství. Praktická část se bude věnovat definici obsahu zadávací dokumentace tak aby v rámci projektu bylo možné využít metodu informačního modelování staveb (BIM).

Seznam doporučené literatury:

1) Metodiky České agentury pro standardizaci
2) Lukas Klee et. al., 2018, International Construction Contract Law 2nd Edition, Willey.
3) Metodiky Státního fondu dopravní infrastruktury

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Jméno a pracoviště druhé(ho) vedoucí(ho) nebo konzultanta(ky) diplomové práce:

Datum zadání diplomové práce: **24.01.2019** Termín odevzdání diplomové práce: **19.05.2019**

Platnost zadání diplomové práce: ______________

Ing. Josef Žák, Ph.D. podpis vedoucí(ho) práce	doc. Ing. Renáta Schneiderová Heralová, Ph.D. podpis vedoucí(ho) ústavu/katedry	prof. Ing. Jiří Máca, CSc. podpis děkana(ky)

III. PŘEVZETÍ ZADÁNÍ

Diplomantka bere na vědomí, že je povinna vypracovat diplomovou práci samostatně, bez cizí pomoci, s výjimkou poskytnutých konzultací. Seznam použité literatury, jiných pramenů a jmen konzultantů je třeba uvést v diplomové práci.

Datum převzetí zadání	Podpis studentky

I declare that submitted master thesis was developed independently under the guidance of Ing. Josef Žák, Ph.D and Ing. Marina Petrochenko, Ph.D.

Furthermore, I declare that all used resources are listed in the List of References.

V Praze dne ……………………….   Podpis ………………………….

Acknowledgements

I would like to thank the supervisor of my master dissertation, Ing. Josef Žák, Ph.D for help with choosing a topic for my dissertation, as well as for leading a thesis at all stages. I would also like to express my gratitude for all his comments, useful tips, provided literature and motivation to work.

In addition, I would like to thank Ing. Marina Petrochenko, Ph.D. for helping me with working on thesis during my stay at Peter the Great Saint Petersburg Polytechnic University. Her knowledge and experience in this field helped me to write this master thesis.

Zadávání zakázek metodou informačního modelování staveb (BIM) pro pozemní stavby

Procurement utilizing building information modeling in civil construction

Anotace

Diplomová práce se věnuje zadávání zakázek metodou informačního modelování staveb (BIM) pro pozemní stavby. Na začátku, práce vysvětluje nejdůležitější pojmy, tykající se BIM, a dále analyzuje zavedené standardy BIM pro pozemní stavby v různých zemích. Další část práce objasňuje význam technických předpisů a popisuje funkce a obsah takových technických předpisů, jako: BIM Protokol, Plán Výkonu BIM (BEP), požadavky na datový standard a požadavky na Společné Datové Prostředí (CDE). Práce dále vysvětluje pojem užití BIM, posuzuje klasifikaci použití BIM z různých zdrojů a provádí porovnání mezi nimi. V závěru práce je představen zpracovaný BIM Protokol, který byl vytvořen na základě zkušenosti a dostupných protokolů různých zemí.

Klíčová slova

BIM, Informační modelování staveb, BIM standard, BIM Protokol, plán výkonu BIM, BEP, datový standard, CDE, Společné Datové Prostředí, Užití BIM

Annotation

The master thesis deals with the procurement utilizing building information modeling in civil construction. At the beginning of the thesis, the most important definitions related to BIM are explained, and an analysis of the established BIM standards for civil engineering in various countries is carried out. The following part of the thesis explains the significance of technical regulations and describes the functions and content of such technical regulations, such as: BIM Protocol, BIM Execution Plan (BEP), data standard requirements and Common Data Environment (CDE) requirements. The thesis further explains the concept of BIM Uses, evaluates the classification of the BIM Uses from different sources, and compares them. At the end of the thesis, the developed BIM Protocol is presented, which was created based on the experience and available protocols of different countries.

Keywords

BIM, Building Information Modelling, BIM standard, BIM Protocol, BIM Execution Plan, BEP, data standard, CDE, Common Data Environment, BIM Uses

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INTRODUCTION

Every year construction is moving more and more forward by introducing new technologies. Nowadays, a lot of companies are moving away from the usual paper projects and are striving to implement 3D modeling. Using the Building Information Modelling (BIM) method has long been gaining popularity around the world. According to buildingSMART (2016), some countries have already implemented mandatory use of BIM in public projects (UK, Finland, Norway, Denmark, Sweden and Netherlands), or are expected to implement mandatory use of BIM in public projects (Russia, Germany, France, Spain and Australia). In a number of countries, such as USA, Canada, China, Brazil and some others, the use of BIM is regular, and in countries such as India, Argentina, Mexico and some others, the use of BIM is only beginning to emerge.

Figure 1 displays the thesis model. The model lists the standards that were reviewed and on the basis of which the content of technical regulations was established. Since all the technical regulations cannot be considered in detail in the thesis, only the BIM Protocol is further investigated, and its structure and content are developed based on the experience and existing protocols in various countries.

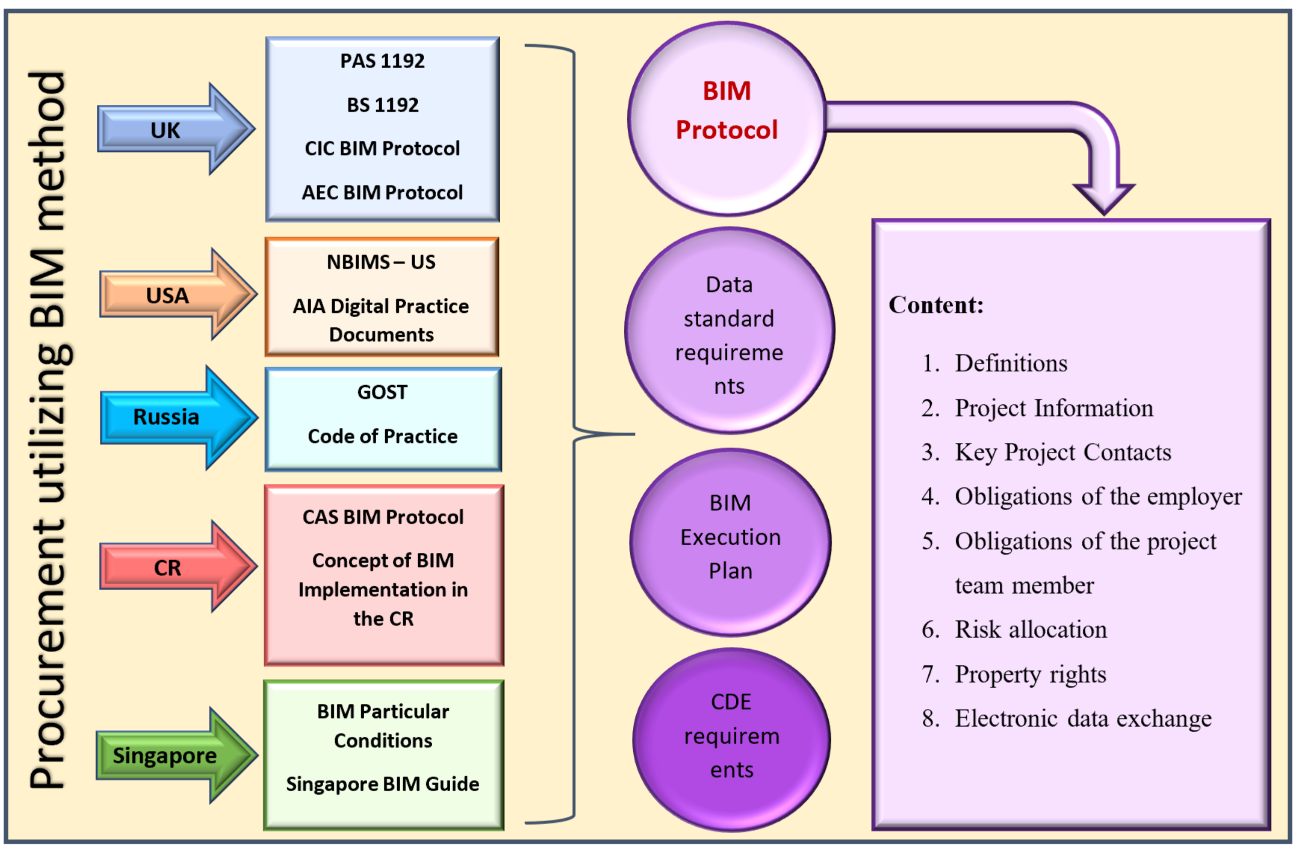


Figure 1: Model of the thesis

The aim and objectives of this dissertation were defined as follows:

Aim

1. Creation of procurement documentation and its content, which is necessary for using the building information modeling method in civil engineering projects.

2. BIM protocol structure development based on the experience of various countries.

Objectives

In accordance with the aims, the following objectives have been set and analyzed in the work:

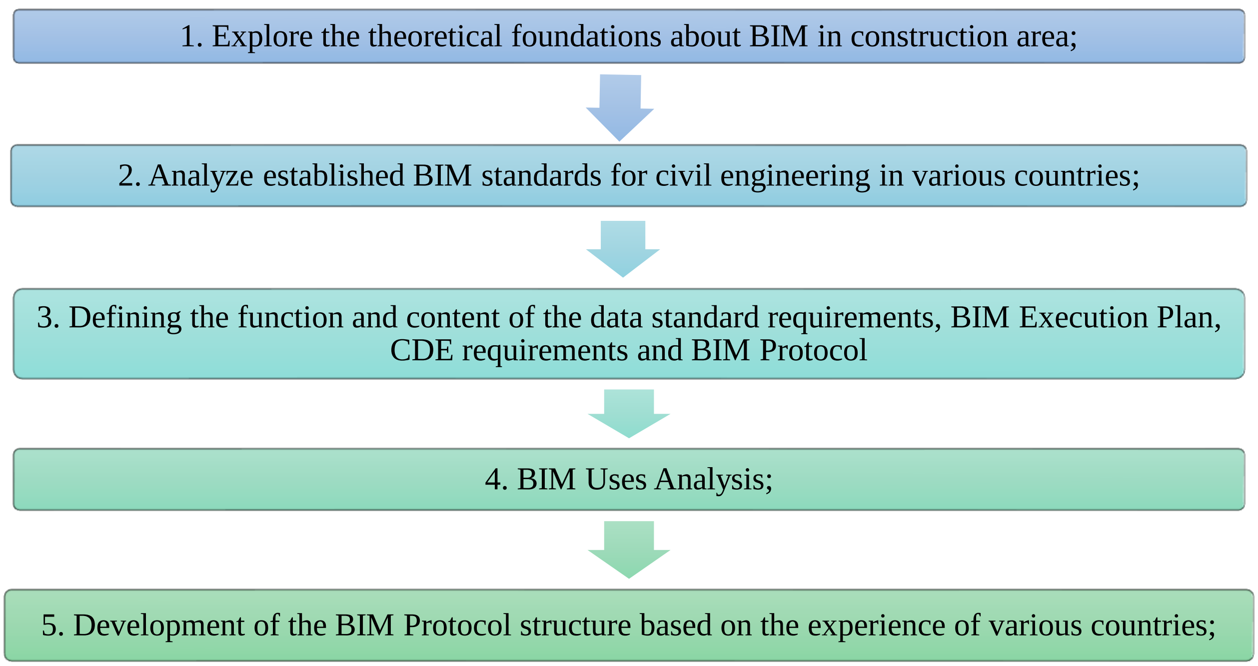


Figure 2: Objectives of the thesis

1 BUILDING INFORMATION MODELLING

This chapter explains the most important definitions related to Building Information Modelling. At the beginning chapter define the definition of Building Information Modelling (BIM) and also describes the main benefits that the using of BIM method brings with it. In addition, this chapter discusses such terms as Level of Development, Level of Definition and Level of Information need, and also describe the difference and their relation to each other.

1.1 Definition of Building Information Modelling (BIM)

In accordance with the results of the research it was revealed that the term BIM for different groups of people has different meanings. For some, BIM is a software application, for others it is a process for designing and documenting building information, for others it is a new approach to practice that requires the implementation of new contracts and relationships between different groups of the project (Aranda-Mena, et al., 2009).

Today, many countries have already developed their own BIM standards, which help to work more effectively on construction projects. These standards will be discussed in more detail in the following chapters. Below are reviewed the definitions of BIM, which are used in BIM standards in the UK and US BIM standard and Singapore BIM Guide.

UK

The UK BIM standard PAS 1192-2 (BSI, 2013) describes Building Information Modelling (BIM) as a process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information.

USA

The US National BIM Standard (2015) defines BIM in three dimensions:

- Building Information Modeling - BUSINESS PROCESS for generating and leveraging building data to design, construct and operate the building during its lifecycle.
- Building Information Model – DIGITAL REPRESENTATION of physical and functional characteristics of a facility.
- Building Information Management - ORGANIZATION & CONTROL of the business process by utilizing the information in the digital prototype to effect the sharing of information over the entire lifecycle of an asset.

Singapore

Singapore BIM Guide (Building and Construction Authority, 2012) consider Building Information Modelling as a collection of defined model uses, workflows, and modelling methods used to achieve specific, repeatable, and reliable information results from the model produced through BIM.

In the Czech Republic, in contrast to the countries listed above, BIM begins to gain momentum relatively recently. In September 2017, the Ministry of Industry and Trade developed the BIM Implementation Concept in the Czech Republic. According to the BIM Implementation Concept (2017), BIM is explained as follows:

> BIM (Building Information Modelling) is a process of creation, utilizing and managing project data throughout its life cycle. "M" can also be viewed as an abbreviation of the word "Management," which better expresses the fact that using BIM allows the management of building information.

The concept also describes the necessity to distinguish between BIM as a model (a certain form of database) and BIM as a process that uses the BIM model to exchange information and also to manage this information. The word building in the definition is not used in the meaning of building construction, but rather involves the construction process as a whole.

1.2 Benefits of BIM

The using of Building Information Modeling method brings with it a number of significant benefits. BIM can be used throughout the entire life cycle of a building and in each phase (planning, design, construction, operation) brings its own benefits.

There was conducted a research by McGraw Hill Construction (2014), in which the contractors from different regions had to select the most important three benefits of BIM for their organization among the fifteen listed. The results of the study are presented in percentage in the Figure 3 below from the highest benefit to the lowest.

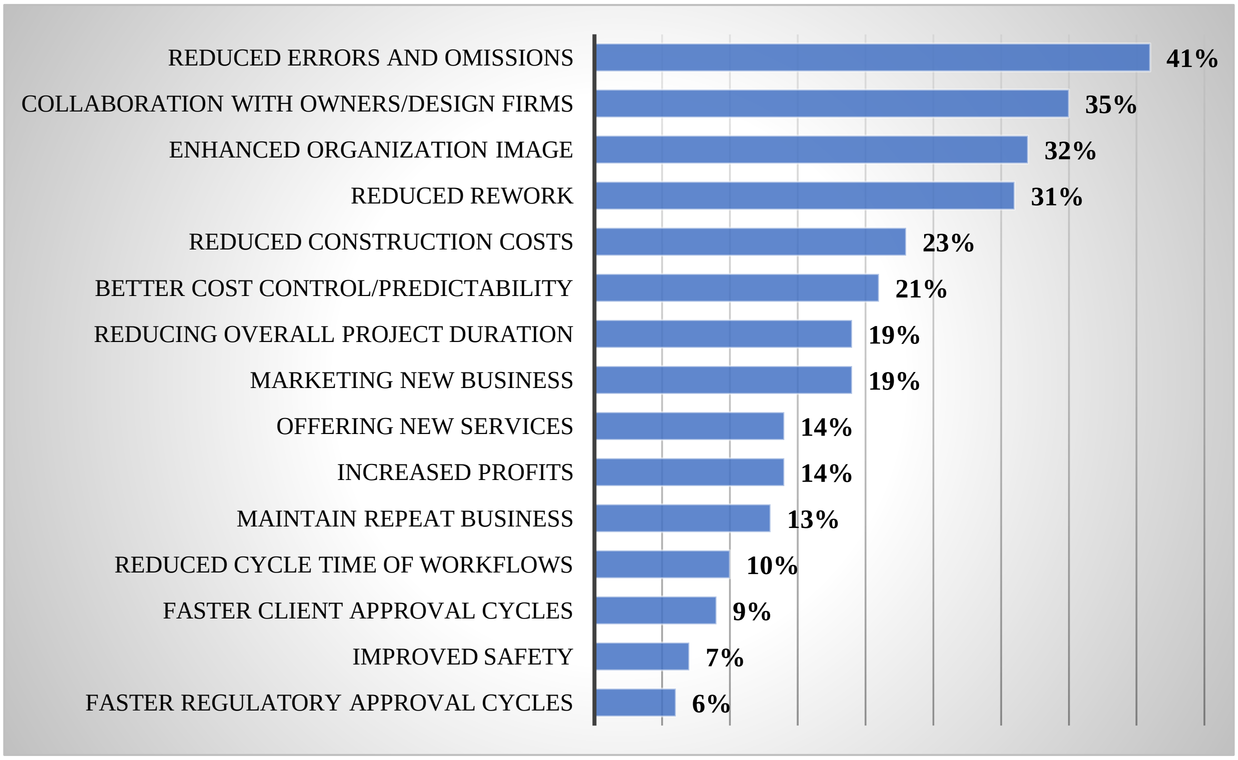


Figure 3:Percentage of contractors citing BIM benefit as one of top three for their organization (McGraw Hill Construction, 2014)

According to the research results shown on the Figure 3, it can be noted that 41% of contractors chose reduced errors and omissions as the main benefit of BIM for their organization. The source for all 2D and 3D drawings is a virtual 3D model of the building, which allows identifying and eliminating errors caused by incompatible 2D drawings before they are found in the field (Eastman, et al., 2011). McGraw Hill Construction (2014) states that reduced errors and omissions benefit in turn leads to other significant benefits shown on the Figure 3, such as reduced rework (31%), reduced construction costs (23%), and the reducing overall project duration (19%).

One of the main benefits of BIM is its ability to respond to the adjustment of parameters and also to analyze the effects of changes, which allows to eliminate errors in the project documentation, improve the productivity and quality of the project (Pittner, 2017). According to Petlach (2017), the use of building information modeling methods will reduce costs by about 10-15% over the entire life cycle of a building. The Figure 4 shows the percentage cost reduction for each construction phase. A significant part of the costs, approximately 70%, can be reduced at the operation phase, and about 27% of the expenses can be reduced at the construction phase.

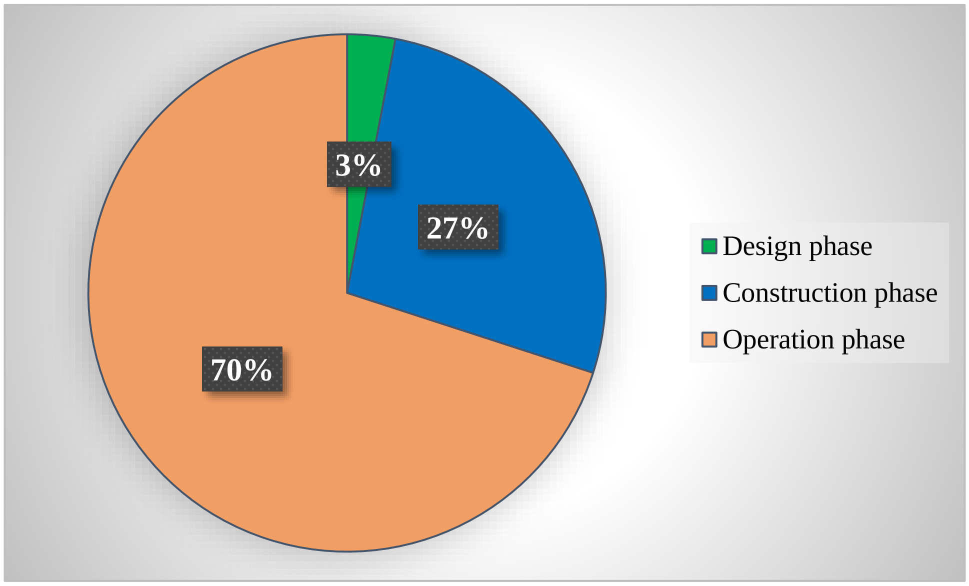


Figure 4: Percentage cost reduction for each construction phase by using BIM (Petlach, 2017)

In accordance with McGraw Hill Construction research (2014), approximately 35% of contractors decided that one of the main benefits of BIM for their organization is collaboration with owners or design firms. Moreover, BIM improves collaboration among various design disciplines. In contrast to the drawings, coordinated three-dimensional models facilitate the simultaneous work of various disciplines, and also provides opportunities for continuous design improvement and the possibility of using value engineering in the early stages (Eastman, et al., 2011).

1.3 Levels of Modelling

BIM projects often use such terms as the Level of Development, Level of Definition, Level of Detail and Level of Information, the meaning of which very often causes misunderstandings among the project team. This is not surprising given the fact that the abbreviation LOD can be used both for the Level of Detail, for the Level of Development, and also for the Level of Definition. This chapter discusses the difference between listed terms and their relation to each other. In addition, this chapter deals with a relatively new term Level of Information need.

1.3.1 Level of Development

The term Level of Development (LOD) is used in the National BIM Standard-United States (NBIMS-US) and according to NBIMS-US (2013) the definition of LOD was developed by the American Institute of Architects (AIA). The meaning of the Level of Development is interpreted in different sources as follows:

"The Level of Development (LOD) describes the minimum dimensional, spatial, quantitative, qualitative, and other data included in a Model Element to support the Authorized Uses associated with such LOD."

(AIA, 2013)

"The Level of Development (LOD) Specification is a reference that enables practitioners in the AEC Industry to specify and articulate with a high level of clarity the content and reliability of Building Information Models (BIMs) at various stages in the design and construction process."

(NBIMS-US, 2013)

"Level of Development is the degree to which the element's geometry and attached information has been thought through – the degree to which project team members may rely on the information when using the model."

(BIM Forum, 2015)

Based on the terms above it is necessary to emphasize that LOD determines not only the geometry of the element in the model, but also information about this element at various construction stages. Another important thing is that LOD determines the degree of reliability of information on which project participants can use and rely. According to the BIM forum (2015), the main difference between Level of Development and Level of Detail, which are often confused, is that *"Level of Detail can be thought of as input to the element, while Level of Development is reliable output."* The term Level of Detail will be discussed in more detail in the chapter Level of Definition.

As stated in AIA Document G202 (2013), there are five descriptions of LOD (LOD 100, LOD 200, LOD 300, LOD 400 and LOD 500), each of which has specific minimum model element content requirements and Authorized Uses. Due to the fact that some information about a model element may be unreliable, a term such as Authorized Uses has arisen, which means the degree to which digital data can be used or the degree of reliability of information (AIA, 2013).

LOD 100 is the lowest Level of Development with minimum model element content requirements. According to AIA (2013), a model element can be graphically represented in a model using a symbol or other general representation but does not meet the requirements for LOD 200.

With the increasing Level of Development (LOD 200, LOD 300), the graphic representation of the model element becomes better and is supplemented with graphic information as quantity, size, shape, location and orientation. In the case of LOD 400, the graphic information is also supplemented with detailing, fabrication, assembly, and installation information. The highest Level of Development LOD 500 is characterized by a field verified representation or as it is also called "as-built Model", which, like previous levels, is provided with such graphic information as quantity, size, shape, location and orientation. Elements of the model can also be supplemented with non-graphic information at each of these levels. (AIA, 2013)

The Figure 5 shows an example of the Level of Development of the foundation with characteristic graphic representation, Level of Detail and Level of Information for each level. The Level of Detail represents graphic or geometric information and the Level of Information in turn represents non-graphic information. The example is taken from the Building Component Catalogue with Level of Development Specification (LOD) developed by MT Højgaard (2016).

The Figure 5 shows that in this example the first three Levels of Development (LOD 100, LOD 200 and LOD 300) are the same as in the American standards. The next level of development in the table is LOD 350, which is not contained in American standards, but can also be used if the element requirements are higher than LOD 300, but not as high as LOD 400. Unlike the American standard, where the highest Level of Development is LOD 500, in this case the LOD specification is limited to LOD 400. This is due to the fact that LOD 500 refers to field verification and is therefore not necessary for additional definition and graphic representation. The same Level of Development principle is used by the BIM Forum (2015) in the Level of Development Specification.

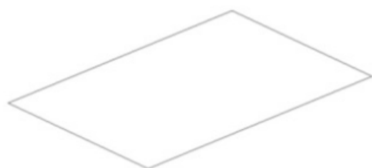
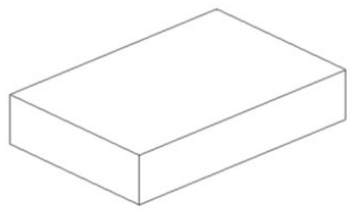
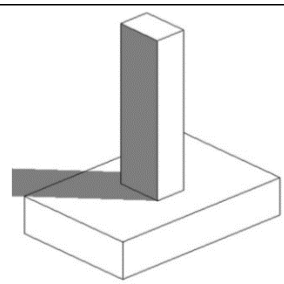
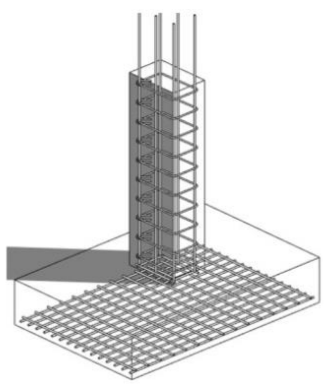
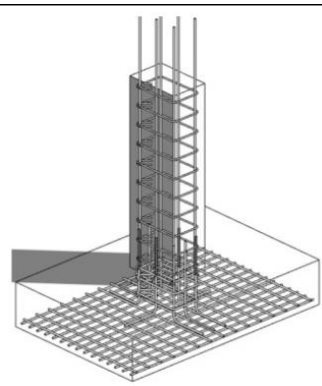
	Graphic representation	LOD	LOI
LOD 100		The foundation location is represented either by the external surface geometry (in plane) and form or by a geometric placeholder with an approximate geometry. The placeholder may be a base plate that shows the entire foundation.	Type Dimensions (approx.)
LOD 200		The foundation is represented as a generic foundation object with an approximate shape, where quantities, size, shape, location and orientation are specified.	Previous information + Elevation + Classification + Materials
LOD 300		The foundation has real quantities, dimensions, shape and location. Moreover, the orientation. Phasing plus slopes and holes plus recesses are included. Reinforcement plus building parts and connection details are clarified	Previous information +Reinforcement degree
LOD 350		The foundation contains holes and recesses. Moreover, the insulation modelled.	Previous information + Concrete strength + Environmental class + Blinding layer + Concrete, coarse
LOD 400		The foundation contains chamfers, location of embedded partsand main reinforcements appears in the model including laps and hooks.	Previous information + Surface Requirements + Elevation Tolerances + Drying Protection + Maturity Hours + Density + Manufacturer/Supplier

Figure 5: Level of Development of the foundation (MT Højgaard, 2016)

The LOD "numbers" system was developed by Vico Software and was originally called the Level of Detail. Later, the American Institute of Architects renamed the system as "Level of Development" in order to note the importance of not only the geometric features, but also the entire content of the BIM for each element. (Grani, 2018)

1.3.2 Level of Definition

The term Level of Definition can be found in British standard PAS 1192-2 (BSI, 2013) and is described by the British Standards Institution (BSI) as a term that includes both a level of model detail and a level of model information or in other words a term that includes both the graphical content of a model and non-graphical content. The concept of Level of Definition is basically the same as Level of Development, but in contrast to the American version, the British Level of Definition is more focused on the stages (Grani, 2018).

The Figure 6 below shows the concept of a matrix in PAS 1192-2 (BSI, 2013), which contains the Levels of Definition in the form of stages (briefing stage, concept design stage, definition stage etc.) and the corresponding information for each stage, such as graphical illustration, what the model can be relied upon for, parametric information, projects costs and so on.

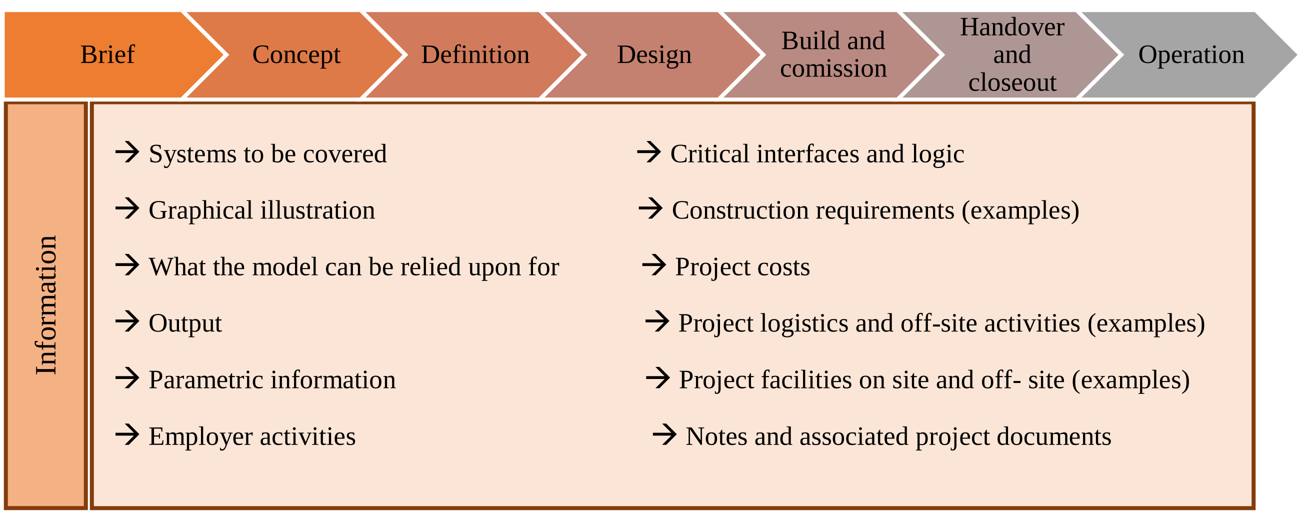


Figure 6: Levels of model definition (own processing using PAS 1192-2: 2013)

PAS 1192-2 (BSI, 2013) emphasizes that an important point is a clear definition of requirements, as well as the need to take into account the fact that too high level of detail than it is necessary can lead to overloading IT systems and networks.

1.3.3 Level of Information Need

The British Standards Institute (BSI), based on the standards of the 1192 series, developed two standards IS0 19650-1 and ISO 19650-2 to help manage information throughout the asset's life cycle using BIM. During the development of the standard, changes were made to the terminology, which was considered ambiguous. Thus, for example, Level 2 BIM is now called Stage 2 BIM, and the collective name for the Level of Detail and the Level of Information has been changed to Level of Information need or LOIN. (Azurelope Ltd, 2019)

A draft version of this standard is now available on the Internet and in accordance with ISO 19650-1.2 (2018), the Level of Information need is a *"framework which defines the extent and granularity of information"* in order to prevent the delivery of too much information. Here again, the norm emphasizes the importance of not exceeding the frame and setting the minimum amount of information that is necessary to determine the relevant requirements.

The Level of Information need is closely related to the federation strategy, which explains how the information model should be divided into one or more sets of information containers during detailed planning. The strategy of the federation and the structure of the breakdown of containers should be updated due to changes in the nature of the work being performed and also when new target groups are appointed. (ISO 19650-1.2, 2018)

2 WORLD'S BIM STANDARDS

This chapter will look at world standards that are used for building information modeling in various countries. The use of standards makes it possible to simplify some processes, reduce costs, and also increase work efficiency. That is why, setting standards has a significant role in the use of building information modeling methods and in construction as a whole.

2.1 UK Standards

Currently, there are more than 34 BIM guidelines and standards in European countries. Most of the developed BIM standards come from the United Kingdom. About 18 standards and guidelines were generally developed and published by Construction Industry Council (CIC), BIM Task Group, British Standards Institution (BSI) and AEC-UK (The BIM Hub, 2016).

2.1.1 Standard Types

UK standards developed by the British Standards Institution (BSI) are divided into PAS (Publicly Available Specifications) and BS (British or international standards) (Barannik, 2016). According to NBS, *"Publicly Available PAS are rapidly-developed standards, specifications, codes of practice or guidelines"* (McPartland, 2017), that do not require lengthy coordination and approval like BS (Barannik, 2016). PAS is designed to meet the urgent needs of the market and in accordance with the recommendations of the British Standards Institution (McPartland, 2017). Two years later, these standards are being revised to determine whether they require revision, whether they should be withdrawn or become official British or international standards. The UK currently uses the PAS 1192 series of standards that specify a collaborative framework and requirements for achieving BIM Level 2 (McPartland, 2017).

The Figure 7 below shows the percentage distribution of used contracts and publications in organizations. About 39% of organizations use BS 1192:2007+A2:2016, which deals with collaborative production of architectural, engineering and construction information. Approximately the same percentage (38%) belongs to the PAS 1192-2:2013, which according to McPartland *"deals with the construction (CAPEX) phase, and specifies the requirements for Level 2 maturity; sets out the framework, roles and responsibilities for collaborative BIM working; builds on the existing standard of BS 1192, and expands the scope of the Common Data Environment (CDE)"* (Malleson, 2017). Also, about 36% of organizations use the new unified plan of work stages, such as the RIBA Plan of Work 2013.

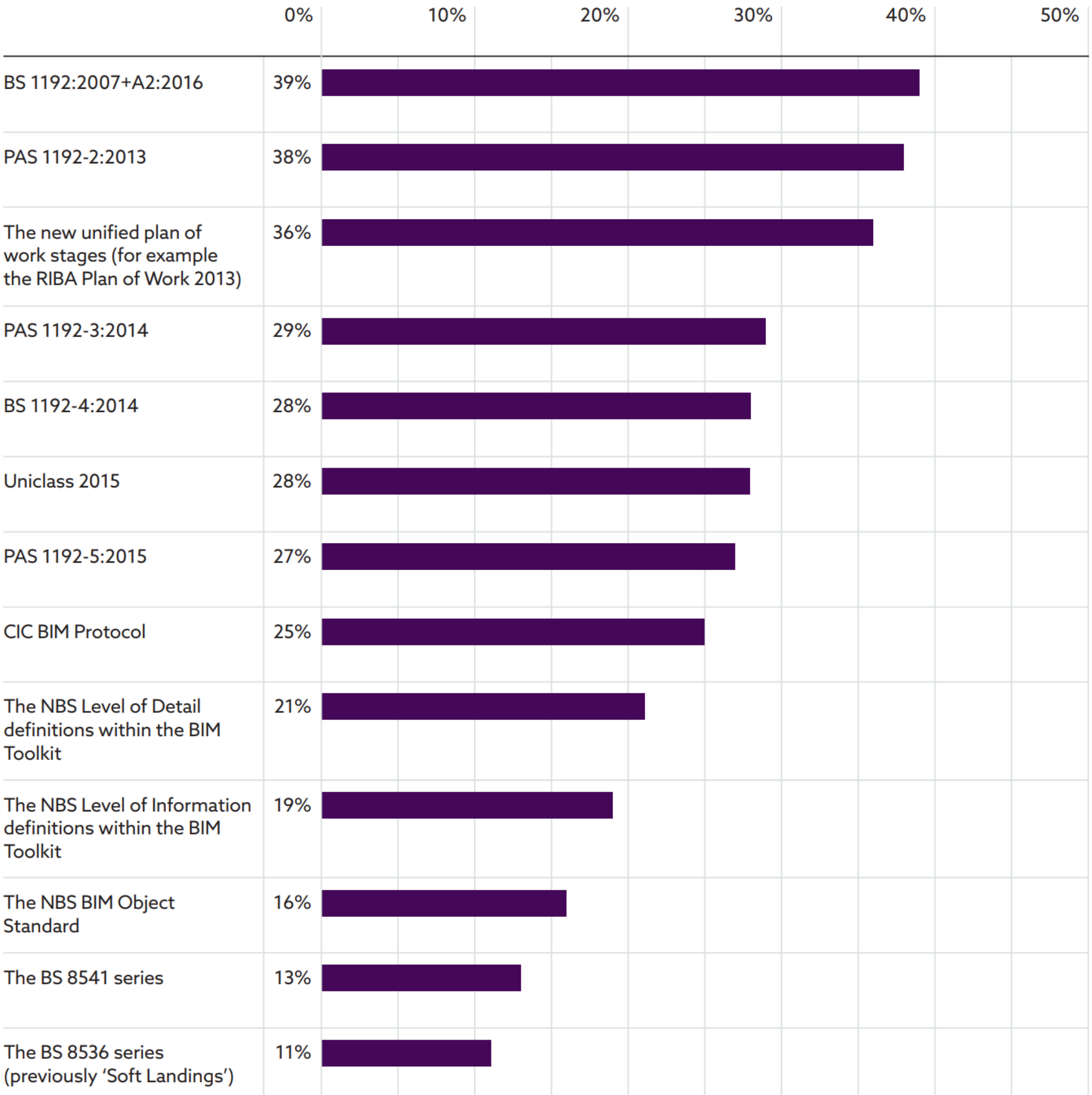


Figure 7: Percentage distribution of used standards/publications (Malleson, 2017)

2.1.2 BIM Maturity Levels

For the transition to full collaboration and productive work, the UK Government has defined clear stages in the form of levels (McPartland, 2014). An overview of all levels is clearly shown in the BIM maturity model in the Figure 8 below, or as it is called, the Wedge diagram. The model represents four levels of maturity levels from the lowest Level 0 to the highest Level 3.

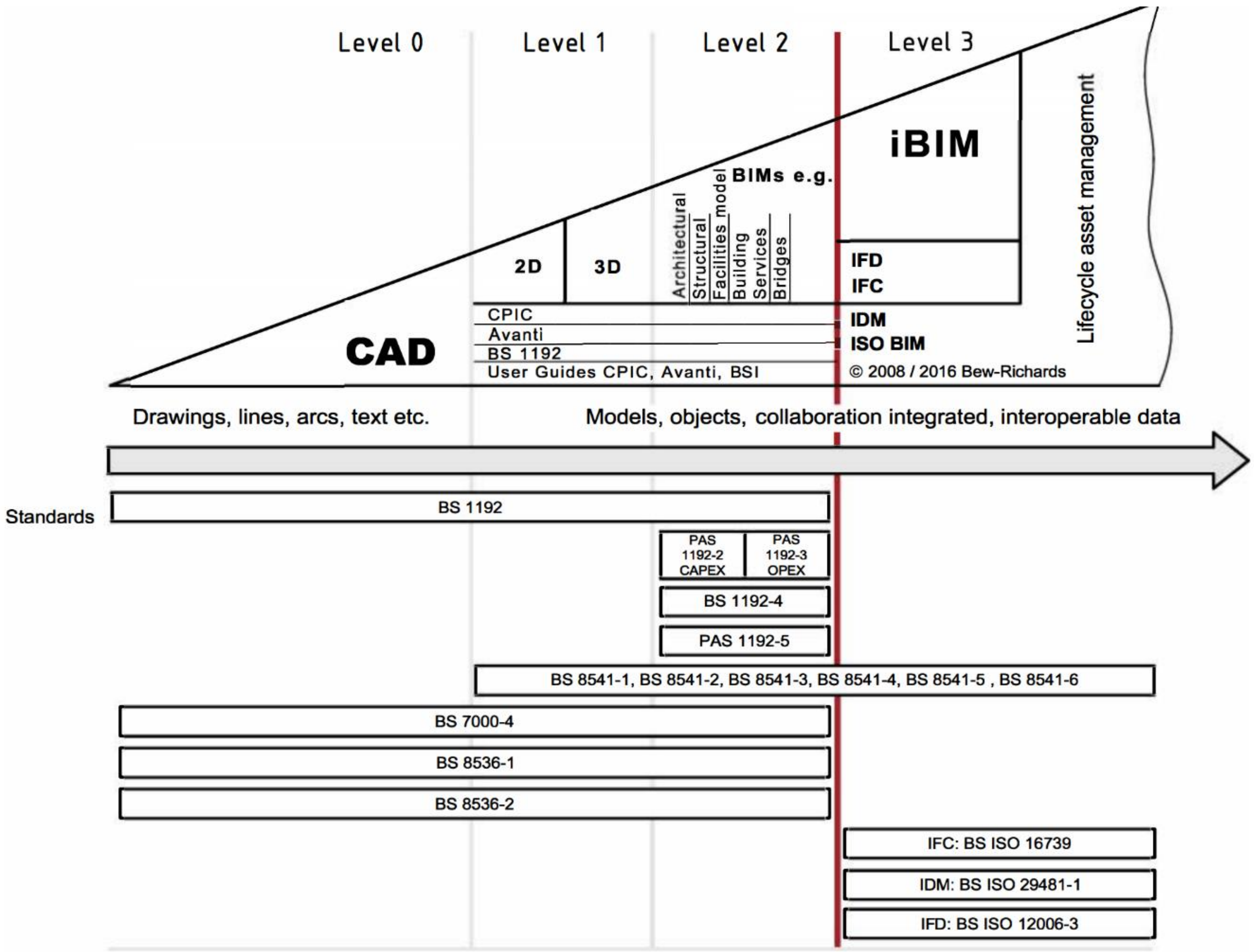


Figure 8: BIM maturity model (BIM Level 2, 2016)

The lowest level 0 is characterized by the lack of cooperation and the use of only 2D CAD drawings in paper or electronic form. Higher level 1 implies the use of both 2D and 3D documentation where data is exchanged using a common data environment (CDE). (McPartland, 2014)

Level 2 models consist of three-dimensional geometric and non-graphic data are characterized by the collaborative work of different project parties in a common data environment throughout the project's entire life cycle (BIM Level 2, 2016). The government of Great Britain established that each party using the CAD software should be able to export to the format of the IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange) format (McPartland, 2014).

The concept of level 3, described in the UK Government's Level 3 Strategic Plan has not yet been fully defined (McPartland, 2014). However, in accordance with the strategic plan, BIM Level 3 is a *"completely integrated approach to the management of asset- and project-related data, where information will be seamlessly available to those who need it in a format that allows different stakeholders to reuse it for different purposes. BIM Level 3 will start to make links with other digital innovations and concepts such as building management systems, smart cities and the Internet of Things (IoT)"* (Malleson, 2017).

2.2 Russian Standards

Currently in Russia there are two types of standards that regulate the direction of information technology in construction: GOST (gosudarstvennyy standart), which means state standard and SP (svod pravil), which means code of practice (Bekh, 2018). GOST is a state standard that contains requirements for the quality of products, works and services that are established on the basis of the achievements of science, technology and practical experience, taking into account the latest editions of international standards or their projects (Slobodyan, 2017). A code of practice is a standardized document containing rules and general principles regarding processes in order to ensure compliance with the requirements of technical regulations (Novikov, 2016).

It should be emphasized that there is no direct hierarchy between GOST and code of practice. In accordance with the government decree of the Russian Federation, there is a list of standards and code of practice, or parts of such standards and code of practice that are obligatory for compliance. Other standards and codes of practice are documents of voluntary application (NormaCS, 2016). Below in the Figure 9 is a list of GOST and code of practice relating to information technology in construction. These standards don't belong to a list of standards and code of practice that are obligatory for compliance. They are rather recommendable to use. The standard code consists of the number and year of approval of the standard.

Standard code	Standard name
GOST R 57310—2016 (ISO 29481—1:2010)	Information modelling in construction. Guide to the delivery of information. Methodology and format.
GOST R 57311—2016	Information modelling in construction. Requirements for the operational documentation of completed construction.
GOST R 57309—2016 (ISO 16354:2013)	Guidelines for knowledge libraries and object libraries.
GOST R 57563—2017/ISO/TS 12911:2012	Information modelling in construction. The main provisions for the development of standards for information modeling of buildings and structures
GOST R ISO 12006—2—2017	Construction. Model of data organization in construction works. Part 2. Basics of information classification.
GOST R ISO 12006—3—2017	Construction. Model of data organization in construction works. Part 3. Basics of the exchange of object-oriented information.
GOST R ISO 22263—2017	Model of data organization in construction works. Structure of project information management.
GOST R 57295—2016	Design-management systems. Guide to design management in construction.
SP 301.1325800.2017	Information modelling in construction. Rules for the organization of work of production and technical departments.
SP 328.1325800.2017	Information modelling in construction. Rules for describing the components of the information model
SP 331.1325800.2017	Information modelling in construction. Rules for the exchange between information models of objects and models used in software packages.
SP 333.1325800.2017	Information modelling in construction. Rules for the formation of an information model of objects at different stages of the life cycle.

Figure 9: Russian standards relating to information technology in construction

2.3 Czech Standards

In September 2017, by decision of the state of the Czech Republic, it was decided to develop the concept of implementation the BIM method, which was developed through the joint work of the Ministry of Industry and Trade, the Ministry of Transport, the state fund of transport infrastructure, and professional experts of the CzBIM council (MPO, 2017). Nowadays there are some technical regulations and methods developed by State Fund of Transport Infrastructure, such as BIM protocol methodology for FIDIC contracts, BIM Execution Plan or for example technical regulations related to Common Data Environment and Data Standards. In February 2019 there was firstly published by CAS a draft of BIM Protocol.

Since 2022, for all over-limit public contracts that are funded by the state, the obligation to use the BIM method, including the development of documentation for the project, comes into force (Katochvilova, 2017). In addition to general information about BIM and analysis of the current state of BIM implementation in the Czech Republic and Europe as a whole, the concept contains a step-by-step plan for implementing BIM in the Czech Republic, and also describes key topics related to BIM, such as estimates, public contracts, copyright, pilot projects and so on (MPO, 2017). According to MPO (2017), as practice shows, changing laws and making amendments is a long and laborious process, therefore, according to the concept, the best solution in this case is to establish the necessary rules in the form of technical regulations that can develop faster.

2.4 USA Standards

In the USA, there are already generally accepted industry standards NBIMS-US (National BIM Standard – United States) developed by the National Institute of Building Sciences buildingSMART alliance, which are used to create and use BIM information models (National Institute of Building Sciences, 2019). In December 2007, the first edition of the standard was published, which laid the foundation for the development of open BIM standards (Architect, 2015).

Later in 2012, an amended version of the National BIM Standard was issued, organized in accordance with ISO/IEC Directives – Part 2: Rules for the structure and drafting of International Standards (NBIM-US, 2012). This version of the standard was the first open consensus standard where construction experts could propose changes that were further reviewed by the NBIMS - US project committee (Architect, 2015). According to Architect (2015), some countries, including South Korea and the UK, have adopted parts of the NBIMS-US V2 in their own BIM standards.

In 2015, based on earlier versions, the third version of the NBIMS was published. Like the previous version, the NBIMS-US V3 was developed as open consensus standard. This version includes concepts such as Construction Operations Building Information Exchange (COBie), Level of Development specifications, and also OmniClass tables. (Architect, 2015)

2.5 Singapore Standards

In May 2012, the first Singapore BIM Guide 1.0 (Building and Construction Authority, 2016) was published. In August 2013, this guide was updated and version 2.0 was released. The Guide describes the roles and responsibilities of project participants when using building information modeling at different stages of a project. In addition, the Guide is also used to develop a BIM Execution Plan that needs to be agreed between project participants. The Singapore BIM Guide consists of both BIM Specifications and BIM Modelling and Collaboration Procedures. The BIM Particular Conditions can be applied to contracts in projects where BIM is used. The BIM Particular Conditions Version 1.0 was originally published as Appendix E in the Singapore BIM Guide Version 1.0. It was updated and revised into the BIM Particular Conditions Version 2.0, released on August 2015. The BIM Particular Conditions include such chapters as definitions, general principles, BIM management, BIM Execution Plan, risk allocation, intellectual property rights, electronic data exchange and termination, rescission or expiry of proncipal agreement.

3. TECHNICAL REGULATIONS FOR PROJECTS USING BIM METHOD

As mentioned in Chapter 2.3, changing laws is a long and complicated process, so the best solution in this case is to establish the necessary rules in the form of technical regulations that can be developed faster. The structure of the technical regulations is based on the structure of the Czech BIM protocol, which not only describes the general principles of the protocol and its content, but also describes the need for additional attachments to the BIM protocol, such as the BIM Execution Plan, Common Data Environment requirements, and data standard requirements. In this chapter, all the specified technical regulations will be considered based on the experience of various countries.

3.1 BIM Protocol

The BIM protocol is one of the most important documents when using building information modeling methods. This chapter will discuss the principles and content of BIM protocols used in various countries.

3.1.1 Principles of BIM Protocol

The BIM Protocol is a standardized legal agreement, which establishes additional obligations and rights between Employer and Supplier and can be incorporated into construction contracts with a simple amendment (The B1M, 2016). According to Synek (2017), BIM protocol supports coordination and cooperation among the participants of the BIM construction project, implements common standards, principles of cooperation and working methods for all parties.

The B1M (2016) emphasizes the need to comply with the following conditions when using the BIM protocol:

- include in each contract the same version of the BIM protocol and its appendices;
- all the information models that will be prepared by each party should be listed in the document;
- except for applications, wording should not be changed;
- any changes should be considered as Contract Variations.

3.1.2 CIC BIM Protocol

The first edition of the protocol by the Construction Industry Council (CIC) was published in 2013. The protocol was drafted in such a way that it could be used with all general construction contracts and also that it could maintain BIM Level 2. Later in 2018, the second edition was published, supplemented by current practices and standards. (CIC, 2018)

The content of the CIC BIM Protocol (2018) consists of following ten chapters:

1. Definitions;
2. Coordination and resolution of conflicts;
3. Obligations of the employer;
4. Obligations of the project team member;
5. Electronic data exchange;
6. Use of information;
7. Liability in respect of proprietary material;
8. Remedies – security;
9. Termination;
10. Defined terms.

3.1.3 AIA BIM Protocol

In June 2013, the American Institute of Architects published a new series of documents related to BIM modeling, one of which was the AIA Document G202-2013, Project Building Information Modeling Protocol Form (BIM Forum, 2018). AIA (2019) states that the purpose of the protocol is to regulate the development, transfer, use and exchange of construction information models of the project. In addition, the protocol establishes requirements for the content of the model in the form of five levels of development and permission to use the contents of the model at each level of development.

AIA Document G202-2013, Project Building Information Modeling Protocol Form includes three articles, such as general provisions, level of development and model element, which will be described in more detail below.

General Provisions

In the first paragraph of the protocol, contact details of all project participants should be added to the table, as well as their role of modeling and individual responsibility. The following paragraph defines what exactly should be included in the model for purposes of the modeling protocols (e.g., architectural models, structural engineering models, specifications etc.). Also, in the chapter General Provisions some paragraphs are devoted to the collaboration protocols, technical requirements, training and support, model standard and also model management protocols and processes.

Level of Development

According to the protocol, The Level of Development *"identify the specific minimum content requirements and associated Authorized Uses for each Model Element at five progressively detailed levels of completeness"*. This term, as well as five Levels of Development, from LOD 100 to LOD 500, was discussed in detail in chapter 1.4.1 above.

Model Elements

This part includes paragraphs about reliance on model elements, coordination and model refinement and model element table. The model elements table indicates the LOD for each model element to be developed at each specified project stage, as well as the author of the model element.

3.1.4 Czech BIM Protocol

There is no standardized BIM protocol in the Czech Republic, like in USA, UK, Germany and other developed countries in the BIM area. Mostly, Czech construction companies create their own version of BIM protocol adapted for their orientation in construction. In February 2019, the Czech Standardization Agency (CSA) published a draft version of the Czech BIM Protocol. In accordance with the CSA (2019), Czech BIM Protocol consists of following chapters:

1. Definitions;
2. General provisions;
3. Priority of contractual documents;
4. Client's obligations;
5. Obligations of the supplier and the project team member;
6. Electronic data exchange;
7. Use of model;

8. Responsibility in relation to the model.

BIM protocol itself is an annex to the main construction contract. In addition to the chapters above, the Czech BIM Protocol also describes the need to attach the next four applications to the BIM Protocol, such as the BIM Execution Plan requirements, project team members, employer's information requirements and common data environment requirements.

3.2 BIM Execution Plan

According to Synek (2018), before starting work on a model, it is necessary to conclude a contractual agreement for the preparation of a BIM model. He also states that it is necessary to conclude an agreement with the contractor to use the model, which will describe the requirements for the model, as well as the method of management and updating the model. This chapter discusses the functions and content of the BIM Execution Plan, which is a tool for achieving the goals described above.

3.2.1 BIM Execution Plan Function

According to PAS 1192-2 (BSI, 2013) BIM Execution Plan is a *"plan prepared by the suppliers to explain how the information modelling aspects of a project will be carried out"*. Synek (2018) defines BEP as a basic document that defines the goals and results of the project, the exchange of information during the implementation of the project and the definition of the information environment. The AEC BIM Protocol (2015) emphasizes that the BIM Execution Plan (BEP) defines how the modeling and exchange of project information should be done, as well as how the model and data should be formatted.

In accordance with the Singapore BIM Guide (Building and Construction Authority, 2013), the BIM Implementation Plan helps the Employer and project participants to coordinate and document BIM results and processes for a project. The goal of BEP is to compile basic information about the design and work with the BIM model at each stage of the building life cycle (Synek, 2018). The development of the BIM Implementation Plan is necessary so that the Employer and the project participants can understand their roles and responsibilities when creating Models at different stages of the project, further identify additional resources and services that may be required; and develop a plan to measure progress throughout the project (Building and Construction Authority, 2013).

3.2.2 The Content of BIM Execution Plan

According to the Singapore BIM Guide Version 2.0 (Building and Construction Authority, 2013), the content of a BIM Execution Plan includes the following:

- Project information;
- BIM goal & uses;
- Each project member's roles, staffing and competency;
- BIM process and strategy;
- BIM exchange protocol and submittal format;
- BIM data requirement;
- Collaboration procedures and method to handle shared Models;
- Quality control; and
- Technology infrastructure & software

According to the British standard PAS 1192-2 (BSI, 2013) BIM Execution plan is divided on pre-contract BIM execution plan and post – contract BIM execution plan. As stated in the PAS 1192-2 (BSI, 2013), the contents of the pre-contract BEP and post contract-award BEP shall consist of everything requested in the EIR plus the following information defined in the Figure 10:

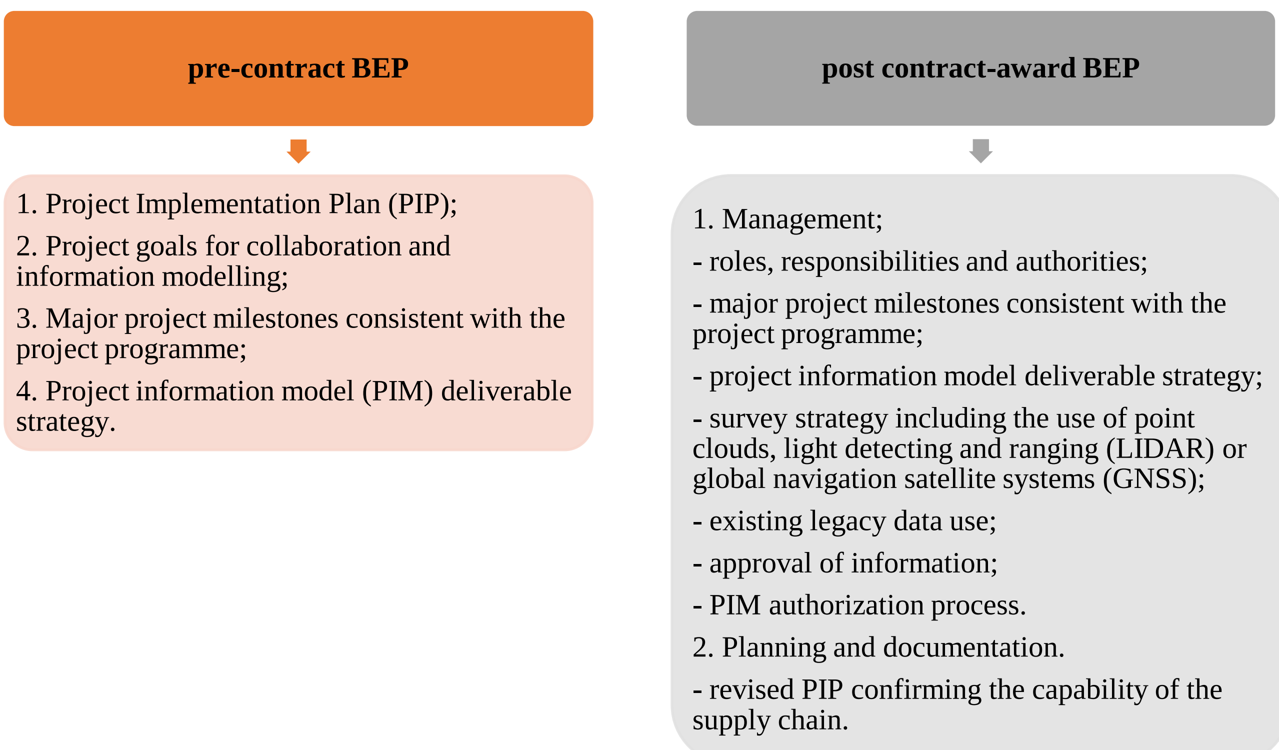


Figure 10: Pre-contract and post-contract award BEP content (own processing using PAS 1192-2: 2013)

3.3 Common Data Environment Requirements

Without an appropriate, functional, and easy-to-use CDE, the BIM model cannot be developed and used, or distributed to project participants (Synek,2018). According to PAS 1192-2 (BSI, 2013) Common Data Environment is a *"single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multi-disciplinary teams in a managed process"*. Working in CDE optimizes information management, supports process management, simplifies and speeds collaboration, distributes responsibilities, uses a centralized data repository, facilitates searching within documents, and also allows integration with existing DMS systems (Synek, 2018).

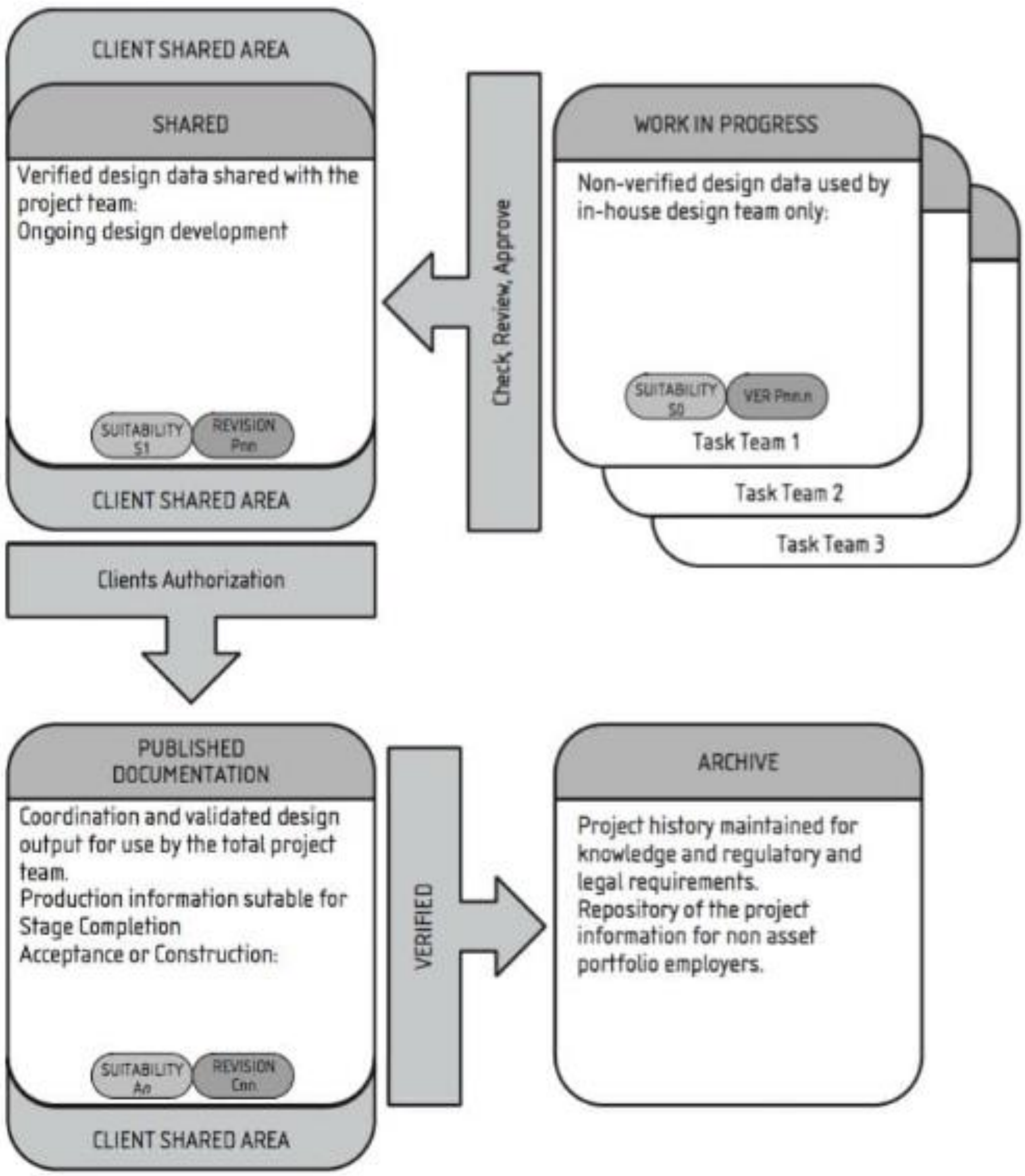


Figure 11: Common Data Environment Areas (BS 1192, 2007)

There are four phases of the CDE as illustrated in the Figure 11. In the Work in Progress (WIP) area, project team members do their own work using the software systems of their organization (BS 1192-2, 2007). According to AEC(UK) BIM Protocol (2015), model data described as work in progress is data that is currently in production and has not yet been controlled and verified for use outside the group of authors. BS 1192 (2007) defines that the quality of the WIP information is the responsibility of the organization, and therefore must provide verification.

Further information enters the Shared area of common data environment, but as emphasized BS 1192 (2007), before information is available to the wider project team, it must be officially verified and approved. All approved information should be stored in the specified place of the Archive, including general, published, replaced and recorded information (AEC, 2015).

According to Synek (2018), CDE also supports the use of open formats (ifc - Industry Foundation Classes - a data format that allows to exchange them between software families, such as Autodesk x Graphisoft), which allows to communicate between different software families.

3.4 Data Standard Requirements

According to Synek (2018), the data standard allows to record the necessary information about any element of the 3D-model and include graphic and non-graphic information compatible with the BIM model environment. He also states, that it is necessary to establish and respect unambiguous rules regarding the structure and syntax of information, and also to take into account that any deviation from the structure and format of a standard makes such information unsuitable for use.

In 2019, the RIBA Enterprises developed industry-wide standard for BIM objects version 2.1 containing the necessary levels of information with the appropriate geometry and which are enclosed in a structured and easy-to-use format. According to RIBA Enterprises (2019), standardization of digital building blocks, or as they are also called BIM objects, will allow participants of various companies, disciplines or geographic areas to cooperate more closely and effectively, as well as to carry out more meaningful information exchange. The BIM Object Standard (NBS, 2019) includes five sections that describe in detail the general, information, geometry, functional and metadata requirements. Figure 12 below shows more detailed description of each section.

Section	Description
1. General requirements	• Object categorization • IFC element type • Predefined type requirements
2. Information requirements	• Property sets • Properties and values • COBie properties • IFC properties
3. Geometry requirements	• Level of geometric detail • Dimensional requirements • Measurement requirements
4. Functional requirements	• Behavioral characteristics • Constraints • Connectivity
5. Metadata requirements	• Naming conventions for files, objects, properties, materials, values and images

Figure 12: BIM Object Standard structure (own processing using NBS, 2019)

In November 2018, the State Fund for Transport Infrastructure (SFTI) of the Czech Republic published the Building Information Modeling Code (BIM) for infrastructure projects - the data standard. The document defines the details of models, construction objects and individual elements, including their properties in accordance with the project phases, and also indicates formats, units of measure, scales, levels of detail, file designations, types of models, properties, color standards and so on (SFTI, 2018).

At the beginning of the document the data base of the data standard and its requirements are considered. The document further describes general requirements (for example, coordinate data, metric system, model property language, etc.), specific requirements related to road and railway construction in this case and also other requirements. In addition, the remaining chapters in the document are devoted to the model structure, the software formats for transferring the model, and also the tolerance.

The document also states that the data standard is similar to the Code of Practice (CoP) and the Employer's Information Requirement (EIR), which are used abroad. According to PAS 1192-2 (BSI, 2013), Employer’s Information Requirements (EIR) is a *“pre-tender document setting out the* *information to be delivered, and the standards and processes to be adopted by the supplier as part of the project delivery process"*. Employer's Information Requirements covers three areas (The B1M, 2015):

- Technical - information format and file types, the minimum Levels of Definition at each stage and the software platforms for exchanging information;
- Management - roles and responsibilities, standards, data security, the key decision points;
- Commercial - client's strategic goal, evaluation of tender participants competence.

4. BIM USES ANALYSIS

4.1 Description of BIM Uses

According to Kreider and Messner (2013) BIM Use can be explained as *"a method of applying Building Information Modeling during a facility's lifecycle to achieve one or more specific objectives"*. Computer Integrated Construction Research Program (2011) emphasizes in the BIM Project Execution Planning Guide, that appropriate BIM uses in a project should be determined based on the characteristics of the project, the goals and capabilities of the participants, as well as the requirements for risk sharing.

4.2 BIM Use Purposes

In accordance with the BIM Project Execution Planning Guide (2011) and CAS (2018), the specific and measurable project goals must be defined before determining the BIM Uses. Examples of such goals are: elimination of clash detections on building site, quick determination of design changes on construction costs, increased construction productivity and so on (CAS, 2018). Kreider and Messner classify the BIM uses based on the goals of implementing BIM, as well as additional characteristics corresponding to each goal. The components of using BIM are clearly shown in the Figure 13.

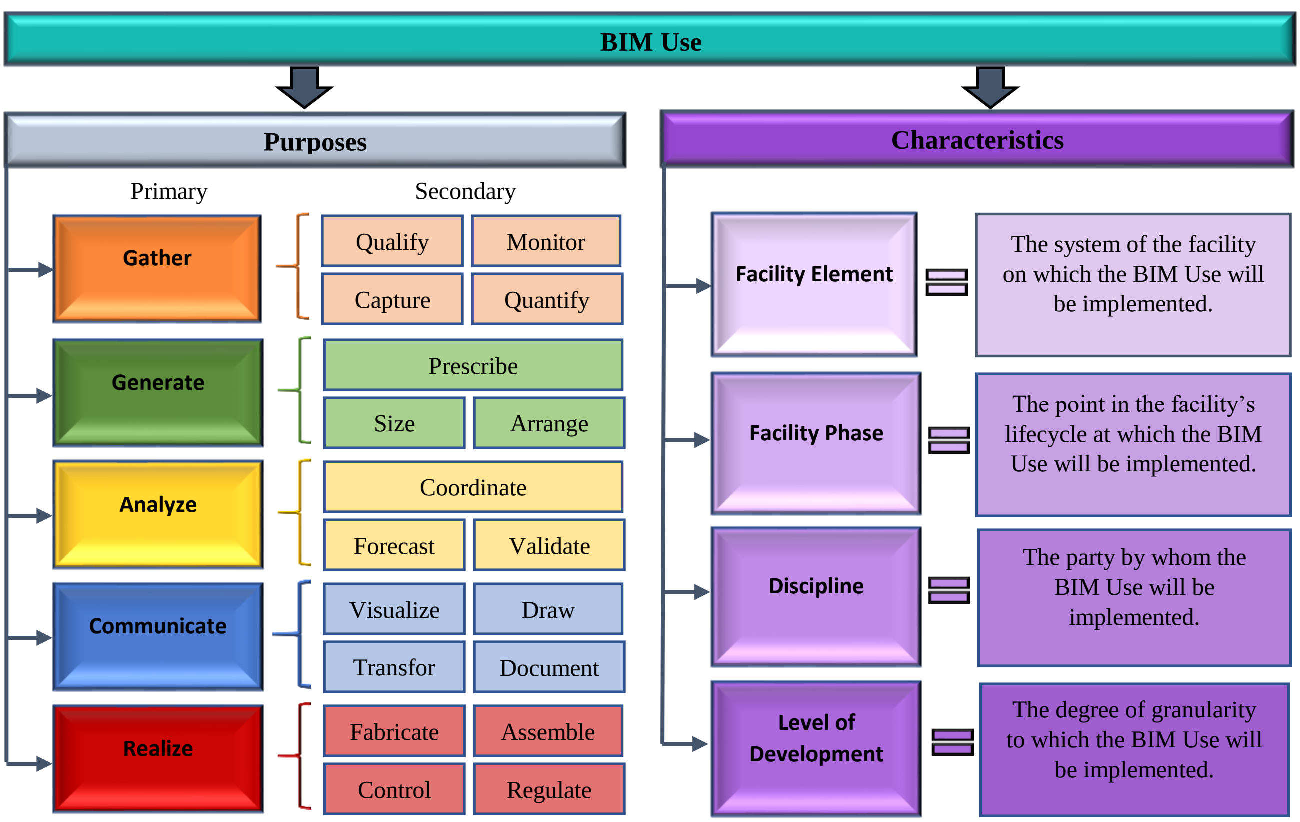


Figure 13: The components of BIM Use (own processing using Kreider and Messner, 2013)

As shown in the Figure 13, BIM Uses are divided into five main groups (gather, generate, analyze, communicate and realize) in accordance with the primary purpose of implementing the use of BIM. In turn, the primary purposes are subdivided into eighteen secondary purposes or, in other words objectives, which define additional goals for using BIM. In addition, the characteristics (facility element, facility phase, discipline and Level of Development) corresponding to each purpose allow to determine the BIM Uses. CAS (2018) emphasizes that the classification of Kreider and Messner (2013) is too abstract and for this reason it was not used in their analysis of the use of BIM.

4.3 BIM Uses Throughout Project's Lifecycle

Some sources classify BIM uses relative to project phases. One such example is the BIM Project Execution Planning Guide (2011), which furthermore states that to determine the BIM uses, the later phases of the project should first be considered. This will determine the necessary information that will be useful at this stage. The BIM Project Execution Planning Guide (2011) defines the 25 primary and secondary BIM Uses, which are clearly shown in the Figure 14.

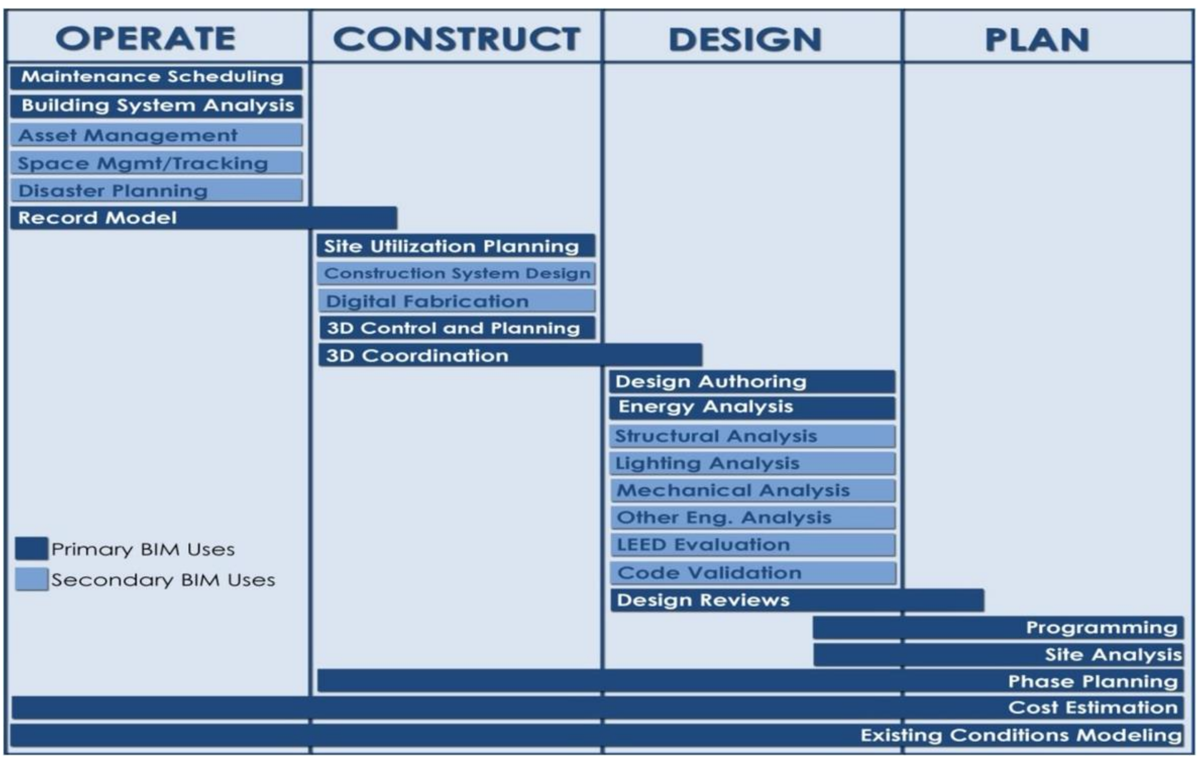


Figure 14: BIM Uses throughout a Building Lifecycle (BIM Project Execution Planning Guide, 2013)

As shown in the Figure 14, all BIM Uses are organized by project phases, starting with the final operation phase and continuing with the construction, design and planning phases. It should also be emphasized that the Guide contains a detailed description and potential value of each BIM Use, as well as the required resources and the required team competencies.

Another example of BIM Uses classification based on project phases is the buildingSMART alliance (2018), which defines 50 BIM uses for the four phases (design, procure, assemble, operate) of a project. Unlike the BIM Project Execution Planning Guide classification, where the planning phase and the design phase are presented separately, in the buildingSMART classification, the planning phase is included in the design phase. The design phase describes twenty-four possible BIM Uses, such as existing conditions modelling, site utilization planning, site analysis, visualization and others. Then the opposite situation occurs where the combination of the two phases considered by buildingSMART represents the construction phase presented by the BIM Execution Planning Guide. The procure phase describes four BIM uses (e.g., product library, manufacturers information, product selection and perform procurement) while the assemble phase describes eleven examples of BIM uses, such as construction system design, phase planning, consistency control and others. The final construction phase describes eleven examples of BIM uses, such as record modeling, asset management, facility management documentation, and others.

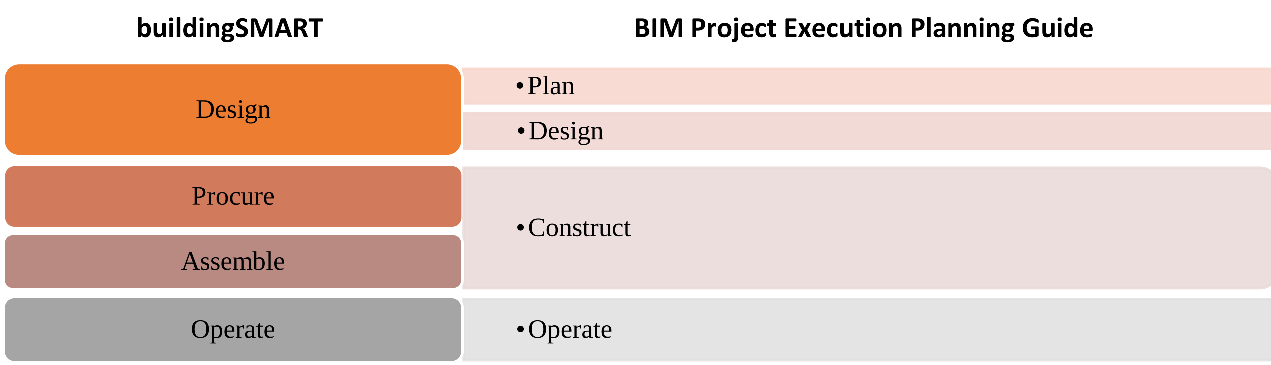


Figure 15: Comparison of buildingSMART and BIM Project Execution Planning Guide phases

The Czech Agency of Standardization (2018) also classifies the use of BIM based on the stages of construction documentation and the corresponding stages of the building life cycle. In comparison with the BIM Project Execution Planning Guide, which described only four phases of the project, the Czech Agency of Standardization (2018) determines eleven phases of the project. There are sixty-two BIM Uses defined by CAS (2018), each of which may correspond to one or more project phases to a greater or lesser extent. Table 16 below presents eleven phases with the corresponding quantities of BIM Uses, as well as several examples of using BIM for each phase.

Phase name	Quantity	Examples
Preparatory work	12	Perform cost analysis, laser scanning, existing conditions modelling
Feasibility study	30	Quantity take-off, perform cost analysis, client’s evaluation
Zoning permit	37	Quantity take-off, client’s evaluation, design creation
Construction permit	44	Quantity take-off, perform energy analysis, perform cost analysis
Detailed design	41	Quantity take-off, perform cost analysis, spatial analysis
Tender documentation	27	Quantity take-off, spatial analysis, perform consistency control
Contractor’s design	35	Quantity take-off, control machinery, construction simulation
Changes during construction	52	Quantity take-off, control machinery, construction simulation
As-built	33	Start commissioning, checking the model content
Operation	44	Quantity take-off, facility management documentation, product information
Demolition	25	Quantity take-off, products information, production documentation

Figure 16: BIM Uses according to CR construction phases (own processing using CSA, 2018)

It is also important to notice, that the disadvantage of this classification was the absence of the detailed description for each BIM Use. For further comparison of BIM Uses from various sources, some phases need to be interpreted as follows:

- Plan (preparatory work, feasibility study)
- Design (zoning permit, construction permit, detailed design, tender documentation)
- Construction (contractor’s design, changes during construction, as-built)
- Operation (operation, demolition)

4.4 Model Use Categories

The BIMe Initiative (2017) states that Model Use defines information requirements that need to be embedded in three-dimensional digital models and subdivides Model Use into the following categories:

1. General: fifty-two Model Uses applicable to all industries and information systems that include the word “modelling” in their name and are usually measured using Level of Definition, Level of Development or Granularity Level (e.g. Architectural Modelling, Renovation Modelling, Sanitary Systems Modelling etc.)

2. Domain: seventy-three industry specific Model Uses organized in seven Model Use Series, which are described in more detail in the Figure 17.

Model Uses Series	Quantity	Model Use Examples
Capturing and representing	9	2D documentation, 3D designing, laser scanning, photogrammetry
Planning and Designing	12	Conceptualization, construction planning, value analysis
Simulating and Quantifying	27	Acoustic analysis, clash detection, cost estimation, site analysis
Constructing and Fabricating	9	3D printing, construction logistics, construction waste management
Operating and Maintaining	7	Building inspection, handover and commissioning, space management
Monitoring and Controlling	5	Building automation, real-time utilization, structural health monitoring
Linking and Extending	7	BIM/FM Integration, BIM/GIS overlapping, BIM/IOT interfacing

Figure 17: Domain Model Uses (own processing using BIMe Initiative, 2017)

3. Custom: Model Uses, which are a combination of General and Domain Uses, which are also able to adapt to any project, client or specific market requirements, if necessary (e.g., modelling security systems for a correctional facility).

Each example of Model Uses has a link to a description of a specific Model Uses in the BIM Dictionary. The BIMe Initiative (2017) states, that Model Uses can simplify the identification of Employer's Information Requirements, facilitate pre-qualification of organizations, as well as the development of modules and lists of project tasks.

4.5 Evaluation of BIM Uses

In accordance with the BIM Execution Planning Guide (2013), the team should discuss and determine how appropriate each BIM Use is for the project, taking into account the team and project characteristics. It is necessary to determine and compare the potential added value or benefit to the project with the cost of implementation. Moreover, it is also necessary to consider the possible risks for each BIM Use. After all factors have been taken into account, the team needs to make a "go / not go" decision for each use of BIM.

The Czech Agency of Standardization (2018) has evaluated each of the sixty-two BIM Uses in terms of usefulness and feasibility. First of all, there were established the usefulness and feasibility of each BIM Use by the expert assessment. Since each BIM Use can refer to several phases of a project at once, the average usefulness number and the average feasibility number for each BIM Use was established. Further, there was calculated the benefit of each BIM Use as the difference between average usefulness and average feasibility. The final step is to calculate the total benefit, which is calculated by multiplying the benefit by the number of phases in which a given BIM Use appears.

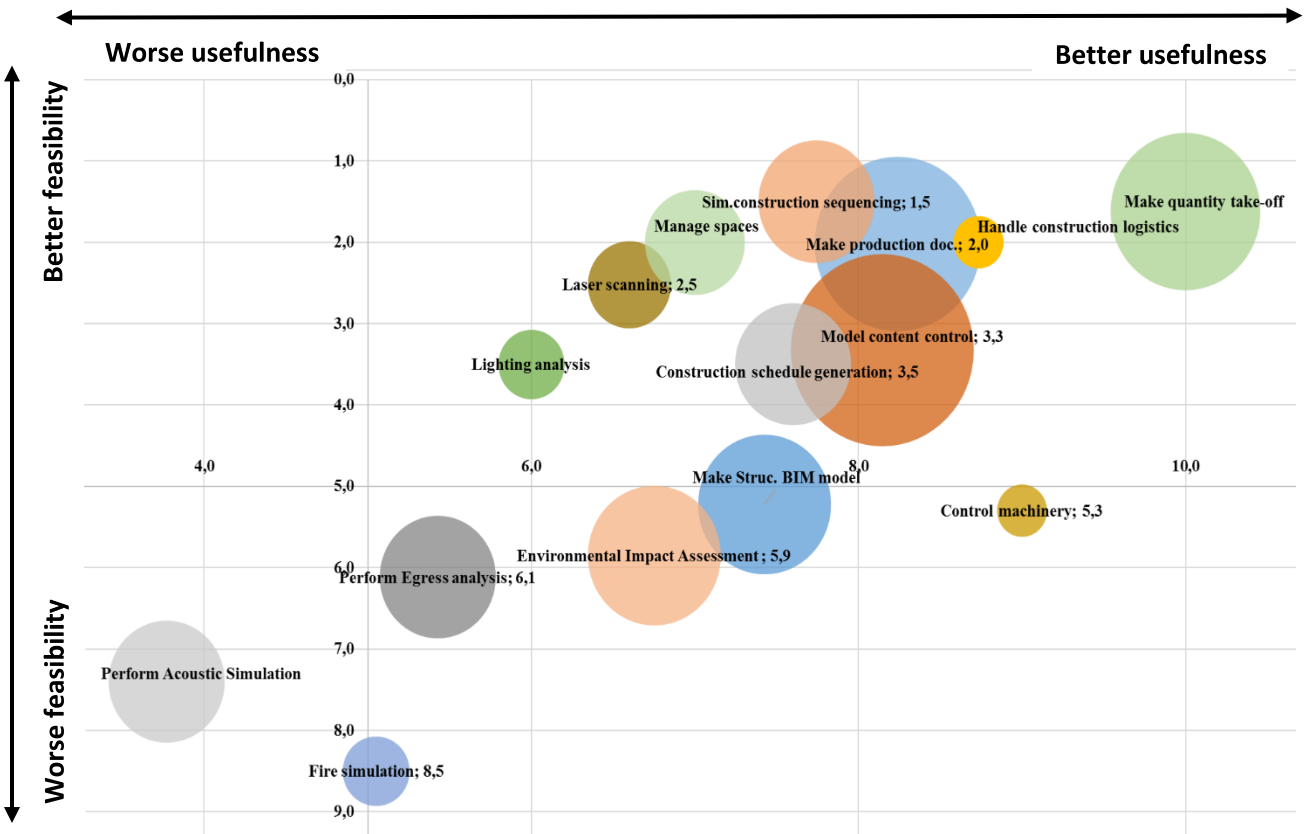


Figure 18: Graphical evaluation of BIM Uses (own processing using CAS, 2018)

Figure 18 presents ten examples of BIM Uses, each of which represents the usefulness and feasibility of BIM Use. For clarity, the Figure 18 shows only ten examples of the sixty-two BIM Uses. The size of the circle is determined by the number of phases in which a specific "BIM use" can be represented. The larger the circle, the more phases this BIM Use refers to.

4.6 BIM Uses Comparison

In previous chapters, various BIM Uses were examined, and it was determined that different sources classify BIM Uses in different ways. Kreider and Messner (2013) divide the BIM Uses into five main groups (gather, generate, analyze, communicate and realize) in accordance with the primary purpose of implementing the BIM Use, which in turn are divided into eighteen secondary purposes that define additional goals for the BIM Uses. In addition, such characteristics as facility element, facility phase, discipline and Level of Development allow to determine the BIM Uses corresponding to each purpose. As mentioned previously, this classification is too abstract.

Many sources, such as BIM Project Execution Planning Guide, CSA and buildingSMART, which were described in the chapter 4.4 divide the BIM Uses in accordance with the project phases. The problem is that each of these sources has a different vision for the number and content of the phases for the project. Which is as well due to country permitting process specifics. To compare the BIM Uses, the project phases were combined in accordance with the Figure 19.

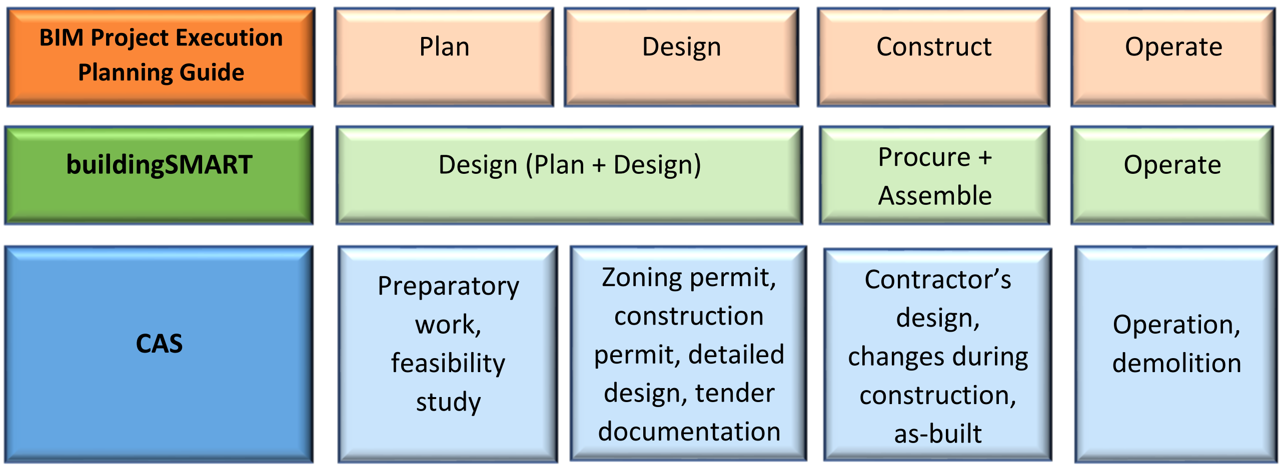


Figure 19: Project phases in relation to BIM Uses

As already mentioned in chapter 4.3, in the buildingSMART classification, the planning phase is included in the design phase. In total, the planning phase includes 24 use of BIM. For further comparison, the design phase will be divided separately into the planning phase and the design phase. The design phase will include all 24 BIM uses. BIM uses such as design to maintain analysis, structural analysis, lighting analysis, energy analysis, mechanical analysis, electrical analysis, other engineering analysis and building system analysis were excluded from the planning phase. Thus, the planning phase includes 16 BIM uses. Both procure and assemble phases belong to construction phase. Also, eleven phases were already mentioned earlier in accordance with CAS, some of which were combined for further comparison as shown in the Figure 19.

In accordance with the Figure 20, it can be noted that even though the number of BIM Uses defined by buildingSMART exceeds the number of BIM Uses determined by BIM Execution Planning Guide, the difference is not significant. It can also be noted that the BIM Uses defined by CAS significantly exceeds the number of BIM Uses defined by the buildingSMART as well as the BIM Execution Planning Guide, especially in the construction and operation phases.

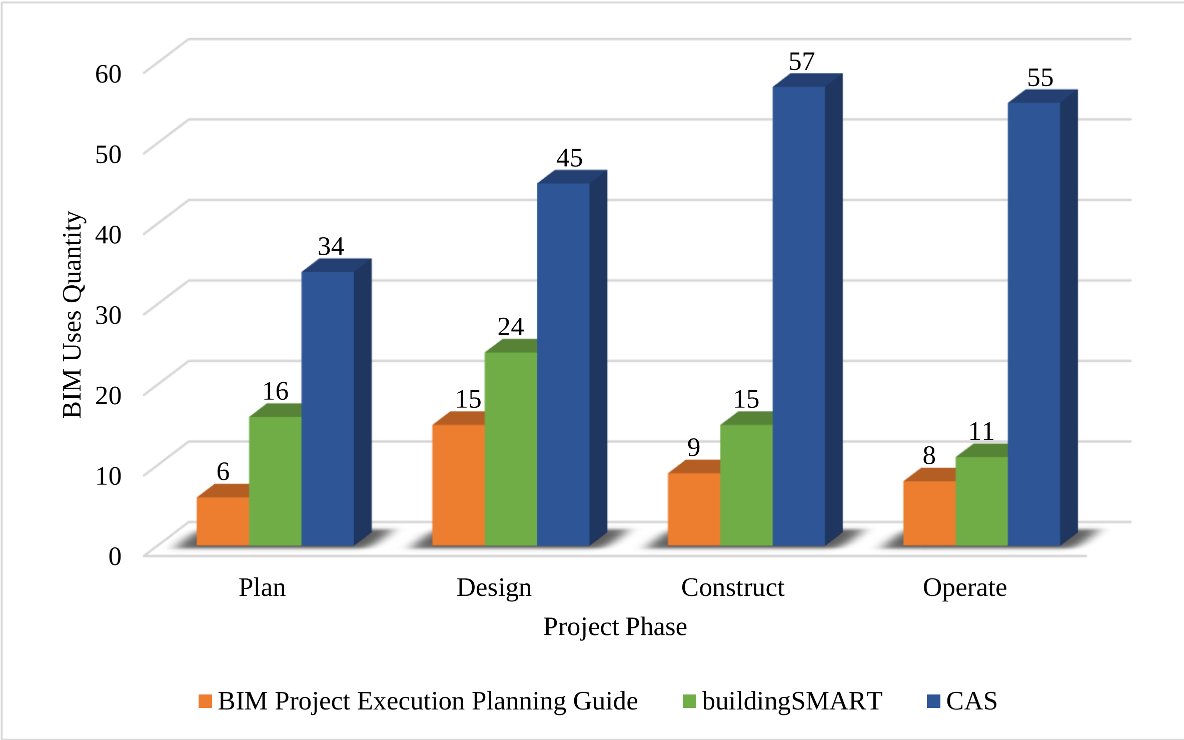


Figure 20: BIM Uses quantity according to project phases

Planning Phase

A comparison of BIM Uses for the planning phase showed that all BIM uses defined by BIM Project Execution Planning Guide, with the exception of the Phase Planning BIM Use, which appears later in the construction phase, are also contained in the buildingSMART classification for the planning phase. The same applies to the BIM Uses defined by CAS. All BIM Uses for the planning phase defined by buildingSMART and BIM Project Execution Planning Guide, with the exception of a few, are also described in the classification of BIM Uses defined by CAS.

Some BIM Uses are described by the CAS in more detail than buildingSMART and BIM Project Execution Planning Guide describe them. The Simulation is one of the BIM Uses for the planning phase in accordance with buildingSMART. CAS, in turn, subdivides the Simulation into three different BIM Uses, such as Simulation in virtual reality, Simulation in augmented reality and Simulation of construction progress. CAS also refers to the planning phase some analyzes (daylight analysis, structural analysis, energy analysis, etc.) and some other BIM Uses (i.e. laser scanning or consistency control) that, in accordance with the buildingSMART and BIM Project Execution Planning Guide, are presented further in the design phase.

BIM Execution Planning Guide		buildingSMART		CAS
Existing Conditions Modeling		Existing Conditions Modeling		Existing Conditions Building/Environment to Design
Cost Estimation		Cost analysis / Estimation		Perform Cost Analysis
Site Analysis		Site Analysis		BIM/GIS Overlapping
				Urban Planning
Programming		Architectural Programming		Manage Spaces
		Spatial Analysis		
Design Reviews		Design Reviews		Investment Project Demonstration
				Client's Evaluation
Phase Planning		Visualization		Visualization in 2D Format
		Simulation		Simulation in Virtual Reality
				Simulation in Augmented Reality
				Simulation of Construction Sequencing
		Quantity Take Off		Quantity Take-Off
		Total Cost of Ownership/ Service Life		LCC Analysis
		Design Authoring and Briefing		Design Creation
				Creating Drawing Documentation
				Creating Architectural BIM Model
				Creating Technology Model (except HVAC)
		Sustainability Evaluation		Evaluation in Terms of Required Certification
				Environmental Impact Assessment
		3D Coordination		Spatial Coordination
		3D Control and Planning		Model Structure Control
		Site Utilization Planning		Model Content Control
		Specification Production		Information Distribution and Data Management in the Project
				Information Distribution and Data Management Outside the Project
				Evaluation in Terms of Affected Public Authorities
				Evaluation in Terms of Other Participants
				Evaluation in Terms of Other Mandatory Management Parameters
				Photogrammetry
				Construction Schedule Generation
				Laser Skanning
				Accessibility Analysis
				Daylight Analysis
				Energy Analysis
				Structural Analysis

Figure 21: BIM Uses comparison for planning phase

Design Phase

As in the previous phase, a comparison of BIM Uses for the design phase showed that all BIM uses defined by BIM Project Execution Planning Guide, with the exception of the Phase Planning and Code Validation BIM Uses, which appear later in the construction phase, are also contained in the buildingSMART classification for the design phase. Also, all BIM Uses for the design phase defined by buildingSMART and BIM Project Execution Planning Guide, with the exception of a few, are also described in the classification of BIM Uses defined by CAS.

BIM Execution Planning Guide	buildingSMART	CAS
Existing Conditions Modeling	Existing Conditions Modeling	
Cost Estimation	Cost analysis / Estimation	Perform Cost Analysis
Site Analysis	Site Analysis	BIM/GIS Overlapping
Programming	Architectural Programming	Manage Spaces
	Spatial Analysis	
Design Reviews	Design Reviews	Investment Project Demonstration
		Client's Evaluation
Design Authoring	Design Authoring and Briefing	Design Creation
		Creating Drawing Documentation
		Creating Architectural BIM Model
		Creating Electrical BIM model
		Creating HVAC BIM model
		Creating Technology Model (except HVAC)
		Creating Structural Model
		Creating Fire Safety Model
LEED Evaluation	Sustainability Evaluation	Evaluation in Terms of Required Certification
		Environmental Impact Assessment
3D Coordination	3D Coordination	Spatial Coordination
Structural Analysis	Structural Analysis	Structural Analysis
Lighting Analysis	Lighting Analysis	Lighting Analysis
		Daylight Analysis
Energy Analysis	Energy Analysis	Energy Analysis
Mechanical Analysis	Mechanical Analysis	
Other Engineering Analysis	Other Engineering Analysis	Other Engineering Analysis
		Egress Analysis
		Acoustic Analysis
		Security Analysis
		HVAC Control Analysis
		Accessibility Analysis
Code Validation	Electrical Analysis	Electrical Analysis
Phase Planning	Visualization	Visualization in 2D Format
	Simulation	Simulation in Virtual Reality
		Simulation in Augmented Reality
		Simulation of Construction Sequencing
		Simulation of Fire Sequencing
	Quantity Take Off	Quantity Take-Off
	Total Cost of Ownership/ Service Life (TCO)	Perform LCC Analysis
	Specification Production	Model Structure Control
	Design to Maintain Analysis	Model Content Control
	Building System Analysis	Evaluation in Terms of Affected Public Authorities
	3D Control and Planning	Evaluation in Terms of Other Participants
	Site Utilization Planning	Evaluation in Terms of Other Mandatory Management Parameters
		Construction Schedule Generation
		Prefabrication (Modularization)
		Maintenance Schedule Generation
		Emergency Plan Creation
		Information distribution and Data Management in the Project
		Information distribution and Data Management outside the Project

Figure 22: BIM Uses comparison for design phase

The quantity of BIM Uses defined by CAS exceeds the quantity of BIM Uses defined by the buildingSMART almost twice, and the BIM Execution Planning Guide three times. This is due to the fact that some BIM Uses in accordance with CAS are described in more detail regarding buildingSMART and BIM Execution Planning Guide. In the previous phase, this has already been shown in the example of the Simulation BIM Use. In the design phase, the Simulation BIM Use, in addition to the Simulation in virtual reality, Simulation in augmented reality and Simulation of construction progress, also includes a Fire simulation. The same principle applies to the Design Authoring BIM Use defined by buildingSMART and BIM Project Execution Planning Guide. CAS devides Design Authoting to the Make production documentation, Make Architectural BIM Model, Make Electrical BIM Model, Make HVAC BIM Model and others.

Construction Phase

Compared to previous phases, BIM Uses defined CAS, BIM Execution Planning Guide and buildingSMART for construction phase have approximately 50% of common BIM Uses. For example, buildingSMART and CAS have such common BIM Uses as Manufacturers Information, Consistency Control, Owner Approval, Laser Scanning and Commissioning. BIM Execution Planning Guide have such common BIM Uses as Construction Planning Design, Phase Planning and others. Compared to buildingSMART and BIM Execution Planning Guide BIM Uses it was noticed that CAS BIM Uses classification describes different analysis and other BIM Uses, such as simulation, quantity take-off etc., that in accordance with buildingSMART and BIM Execution Planning Guide belong to previous design phase.

BIM Execution Planning Guide		**buildingSMART**		**CAS**
Construction System Design		Construction System Design		Design Creation
				Creating Drawing Documentation
				Creating Architectural BIM Model
				Creating Electrical BIM model
				Creating HVAC BIM model
				Creating Technology Model (except HVAC)
				Creating Structural Model
				Creating Fire Safety Model
				Security Elements Modelling
Existing Conditions Modeling				Existing Conditions Building/ Environment to Design
Phase Planning		Phase Planning		
Digital Fabrication		Digital Fabrication		Prefabrication (Modularization)
Cost Estimation				Perform Cost Analysis
3D Coordination				Spatial Coordination
Record Model		Owner Approval		Client's Evaluation
3D Control and Planning		Laser Scanning		Laser Scanning
Site Utilization Construction Phase		Commissioning		Start Commissioning
		Field & Material tracking		Construction Logistics Management
				Delivery Schedule Generation
		QA/QC - Consistency control		Model Structure Control
				Model Content Control
		Manufacturers Information		Structures and Products Information
		Product Library		
		Product Selection		
		Perform procurement		Quantity Take-Off
		Code Validation		Investment Project Demonstration
		Digital Layout - BIM 2 Field		BIM/GIS Overlapping
		Pay Applications		Information Distribution and Data Management in the Project
				Photogrammetry
				Visualization in 2D Format
				Simulation in Virtual Reality
				Simulation in Augmented Reality
				Simulation of Construction Sequencing
				Simulation of Fire Sequencing
				Simulation of Construction Sequencing in Terms of Safety
				Egress Analysis
				Energy Analysis
				Structural Analysis
				Electrical Analysis
				HVAC Control Analysis
				Security Analysis
				Lighting Analysis
				Daylight Analysis
				Acoustic Analysis
				Accessibility Analysis
				Other Engineering Analysis
				Control Machinery
				Making Changes in Land Registry
				Evaluation in Terms of Required Certification
				Environmental Impact Assessment
				Evaluation in Terms of Affected Public Authorities
				Evaluation in Terms of Other Participants
				Perform LCC Analysis
				Construction Schedule Generation
				Maintenance Schedule Generation
				Emergency Plan Creation
				Manage Spaces
				Integration With Enterprise Systems
				Monitor Building
				Creation of Facility Management Documentation

Figure 23: BIM Uses comparison for construction phase

Operation phase

BuildingSMART and BIM Execution Planning Guide have approximately the same quantity of BIM Uses. BIM Uses in accordance with CAS exceed the quantity of buildingSMART and BIM Execution Planning Guide five times. In accordance with the operation phase, it was noticed that all BIM Uses of BIM Execution Planning Guide also include in their classification buildingSMART or CAS or even both of them. Compared to buildingSMART and BIM Execution Planning Guide BIM Uses it was noticed that CAS BIM Uses classification describes different analysis and other BIM Uses, such as simulation, quantity take-off etc., that in accordance with buildingSMART and BIM Execution Planning Guide belong to previous design phase.

BIM Execution Planning Guide		buildingSMART		CAS
Existing Conditions Modeling				Existing Conditions Building / Environment to Design
Cost Estimation				Perform Cost Analysis
Record Model		Record Modeling		
Space Mangement or Tracking		Space Management and Tracking		Manage Spaces
Asset Management		Asset Management		
Maintenance Scheduling		Building (Preventative) Maintenance Scheduling		Maintenance Schedule Generation
Disaster Planning		Disaster Planning / Emergency Preparedness		Emergency Plan Creation
Building System Analysis				Energy Optimization
		FM Documentation		Integration With Management and Maintenance Systems
		Security & Key Management		Design Creation
		Communication move/add/change management		Creating Drawing Documentation
		Way finding		Creating Architectural BIM Model
		As Constructed Modeling		Creating Electrical BIM model
		Maintenance & Repair Information		Creating HVAC BIM model
				Creating Technology Model (except HVAC)
				Creating Structural Model
				Creating Fire Safety Model
				Prefabrication (Modularization)
				Spatial Coordination
				Laser Scanning
				Construction Logistics Management
				Delivery Schedule Generation
				Model Structure Control
				Model Content Control
				Structures and Products Information
				Quantity Take-Off
				Investment Project Demonstration
				BIM/GIS Overlapping
				Information Distribution and Data Management in the Project
				Information distribution and Data Management outside the Project
				Photogrammetry
				Visualization in 2D Format
				Simulation in Virtual Reality
				Simulation in Augmented Reality
				Simulation of Construction Sequencing
				Simulation of Fire Sequencing
				Egress Analysis
				Structural Analysis
				Electrical Analysis
				HVAC Control Analysis
				Security Analysis
				Lighting Analysis
				Daylight Analysis
				Acoustic Analysis
				Accessibility Analysis
				Other Engineering Analysis
				Control Machinery
				Making Changes in Land Registry
				Evaluation in Terms of Required Certification
				Environmental Impact Assessment
				Evaluation in Terms of Affected Public Authorities
				Evaluation in Terms of Other Participants
				Evaluation in Terms of Other Mandatory Management Parameters
				Perform LCC Analysis
				Construction Schedule Generation
				Integration With Enterprise Systems
				Monitor Building

Figure 24: BIM Uses comparison for operation phase

5 BIM PROTOCOL DEVELOPMENT

5.1 Definitions

This chapter is an integral part of every BIM protocol. The chapter contains definitions for the necessary terms that are used in the BIM protocol. The list of terms with their definitions will help to avoid misunderstandings in understanding the content of the protocol. All definitions, except Model Users and Digital Data were taken from the CIC BIM Protocol (2013). The definition of Model Users was taken from the Singapore BIM Particular Conditions and the definition of Digital Data was taken from Guide, Instructions and Commentary to the 2013 AIA Digital Practice Documents developed by AIA (2013).

5.2 Obligations of the Employer

In accordance with CAS (2018), one of the Employer's obligations is to consider Employer's Information Requirements, including data standards, as well as update them, if necessary. The CIC BIM protocol (2013) states that, in addition to informational details, the employer must also consider the Responsibility Matrix and update it at each stage of the project. Further, the CAS (2018) and CIC BIM protocol (2013) state that the Employer must ensure the appointment, change or update of the Information Manager as needed until the end of the project.

The CIC BIM protocol (2013) also establishes some Employer's obligations regarding the Common Data Environment (CDE). First, the Employer must provide the Project Team Member with the opportunity to use the CDE to the extent that the Project Team Member needs to fulfill the agreement. Secondly, the Employer is obliged to provide Project Team Members with access to the sharing of project information in order to keep information at the end of the project, as well as in the event of an early termination of the agreement. According to CAS (2018), the Employer should build their relationships with Project Team Member based on an understanding of mutual expectations and trust, as well as based on joint efforts to achieve agreed common goals.

In addition to the above, the CIC BIM protocol (2013) also states the need to review Security Requirements, as well as update them at each stage of the project, if necessary. The Employer must also appoint, change or update the Security Manager as needed until the end of the project.

5.3 Obligations of the Project Team Member

The difference between the two BIM Protocols is that the CIC BIM Protocol (2013) describes the obligations of the Project Team Member, while the CAS BIM Protocol (2018) describes separately the obligations of the Contractor and other Project Team Members (except the Employer and the Contractor). In accordance with the CIC BIM Protocol (2018), the Project Team Member must provide the Specified Information, taking into account events or circumstances that give the Project Team Member the right to an extension or additional time in accordance with the Agreement. Also, the Project Team Member is obliged to provide the Specified Information at the Level of Definition and at the Project stage, which are specified in the Responsibility Matrix, Information Particulars or any other part of the Agreement, using the Common Data Environment (CDE) for exchanging or publishing the Specified Information.

The CAS BIM Protocol (2018) first of all states that the Contractor and other Project Team Members are obliged to follow the Protocol and the BIM Execution Plan (BEP). The Contractor is also obliged to ensure that Project Team Members, including all Subcontractors of the Contractor, but excluding the Employer, are bound by the Protocol. In addition, the contractor and Project Team Members should build their relationships with the Employer based on an understanding of mutual expectations and trust, as well as based on joint efforts to achieve agreed common goals. Further, the Project Team Member is obliged to ensure the processing of personal data in accordance with the general data protection regulations. The Contractor must also ensure that all Project Team Members, with the exception of the Employer, are bound by protocol.

Further CAS BIM Protocol (2018) emphasizes that the Contractor and other Project Team Members are required to provide an Information Model, or part of the model, at the Level of Development to the corresponding specified stage in accordance with the Employer's Information Requirements, data standards and other annexes to the Agreement. The Information Model, or part of the model, may be used by Contractors or other project team members only in accordance with Acceptable Objectives.

In accordance with the CAS BIM Protocol (2018), the contractor and other project team members must provide information models, drawings and related documents in the specified formats. Information models should be provided in the open .ifc format (Industry Foundation Class) in accordance with EN ISO 16739, as well as in the proper format of the necessary software tool for creating an information model. Drawings should be provided in their own format, and related documents in open or in public formats (.doc, .docx, .xls, .xlsx) for further processing.

In addition to the above, the CAS BIM Protocol (2018) states that the contractor must also comply with the following obligations:

- Make sure that current information requirements and data standards of the Client are always respected;
- Ensure the relevance of the data, which the Contractor added to the Common Data Environment (CDE);
- Provide the required specification of the BIM Execution Plan (BEP) that meets the needs and requirements of the Client;
- Provide an update of the BIM Execution Plan (BEP) before preparing the project documentation at each stage in accordance with the contract, the client's information requirements and data standard.

The CIC BIM protocol (2013) contains some rules regarding the security of information. In accordance with these rules, the Project Team Member must interact with the Built Asset Security Manager and must also comply with parts of Security Requirements that relate to confidential information.

5.4 Risk Allocation

In accordance with the Singapore BIM Particular Conditions (Building and Construction Authority, 2015), Model Users can rely on the accuracy and completeness of the Released Model only to the extent required for the Level of Detail (LOD) specified in the BIM Execution Plan (BEP). The Model Users exercise at their own risk and without liability to the Author of the model any use of the content of the Released Model that exceeds the Level of Detail specified in the BIM Execution Plan.

Singapore BIM Particular Conditions (Building and Construction Authority, 2015) state that each Model Author in relation to its contribution should meet the standard of care in accordance with the party's Principal Agreement. Holland (2019) defines the common standard of care as "*the ordinary and reasonable care usually exercised by one in that profession, on the same type of project, at the same time and in the same place, under similar circumstances and conditions*". Singapore BIM Particular Conditions (Building and Construction Authority, 2015) emphasize that in case the standard of care is not established, then the standard of care should be the appropriate degree of qualification, care and diligence expected from a competent person engaged in BIM and performing the same role or scope of works as that Model Author on the project.

In addition to the above, Singapore BIM Particular Conditions (Building and Construction Authority, 2015) state that each project participant should make efforts to minimize the risk of claims and liability arising from the use or access to the released models. Each participant must immediately inform the relevant party and the BIM manager of any errors, inconsistencies or omissions found in the released model.

5.5 Property Rights

According to AIA (2013), sharing files carries the risk of losing control and ownership of shared files, as well as their copyright. In order to protect the owner of the digital data, it is important that the accepting party understands and agrees with the restrictions of use. This chapter will cover the copyrights that are an integral part of each BIM Protocol.

The CIC BIM Protocol (2013) states that any rights, including copyright, existing in the Material, as well as any proprietary works contained in or derived from the Material, should, depending on the circumstances, remain in the ownership of the Project Team Member. Under the definition of Material means the Specified Information prepared by the Project Team Member under the Agreement. In accordance with the CAS BIM Protocol (2018) and Singapore BIM Particular Conditions (Building and Construction Authority, 2015), the copyright to the information model and the protected work contained in the information model is owned by the project team member who created it. In addition, the CAS BIM Protocol (2018) states that each project team member (including the contractor), upon the Employer’s request, must immediately confirm that he is bound by this protocol and also sign a sublicensing agreement between them.

The protocol should also describe the clauses regarding the provision of a license to an Employer by the Project Team Member. CIC BIM Protocol (2013) and Singapore BIM Particular Conditions (Building and Construction Authority, 2014) emphasize that the Project Team Member grants the Employer a non-exclusive, free and irrevocable license, as well as a sub-license, if the rights belong to third parties, which allow to distribute, copy, display and use the Material for the permitted purpose. CAS BIM Protocol (2018) states that the Employer and the Project Team Member agree on a license to use the License Subject, which grants the Employer right to use intellectual property rights for all uses worldwide (territorially unlimited), to an unlimited extent or to the maximum extent permitted by law.

In accordance with the CIC BIM Protocol (2018), any license or sub-license granted by a member of the project team to the employer should not include the right to make changes to the Material without written confirmation of the project participant, except in cases where such change is provided for in the Employer's Information Requirements or when such a change is made after dismissal member of the project team in accordance with the agreement.

According to CAS (2018), Employer becomes a legal licensee not only by agreeing on a protocol with project team member, but also at the moment when a project team member begins to participate in the production of an information model without specifically agreeing on a protocol. The project team member must provide a license to the employer for the period of copyright for the subject of the license. Since the employer's license is exclusive, a member of the project team does not have the right to grant any license to use the Subject License to any third party. The Protocol also emphasizes that license of the employer is granted without the right to remuneration from the employer.

The protocol should also describe the clauses regarding the provision of a license to a Project Team Member by the Employer. According to the CIC BIM Protocol (2013) and CAS BIM Protocol (2018) the Employer grants to the Project Team Member a non-exclusive sub-licence to transmit, copy and use any Information Model that forms part of other Information Models or any data that forms part of other Information Model or any proprietary work contained in such an Information Model owned by the Other Project Team Members or any other third party for the Permitted Purpose. Both protocols also emphasize that licenses and sub-licenses submitted to the project team member by the employer should not include changes to the information model or any part of it without the written approval of the Employer or any other member of the project team who created this model, except in cases where such change is provided for in the Employer's Information Requirements or when such a change is made after dismissal member of the project team in accordance with the agreement.

5.6 Electronic Data Exchange

According to AIA (2013), when exchanging Digital Data, the Party receiving the Digital Data must trust that it is free to receive and use the information provided. Therefore, the transmitting Party is obliged to ensure that it is either the copyright holder of the transmitted information or has permission from the copyright holder to transmit information for use in the Project.

CIC BIM Protocol states that project team member does not guarantee that any software used to prepare the specified information or any software format in which such information is transmitted, published or otherwise produced in accordance with this Protocol and Agreement is compatible with any software or software format used by the Customer or on its behalf, the Information Manager of the employer or any other team member project in connection with the project.

According to the CAS BIM Protocol (2018), Singapore BIM Particular Conditions (Building and Construction Authority, 2015) and CIC BIM Protocol (2018), the project team member is not liable to the Employer in connection with any corruption or inadvertent change, modification or alteration of electronic data in any Specified Information that appears after it has been transmitted, published or otherwise released within the CDE process. unless this is the result of the Member's failure to comply with the project team of this Protocol and / or Agreement.

AIA (2013) states, that the transfer of Confidential Digital Data is a guarantee for the Party receiving such Confidential Digital Data that the transmitting Party has the right to transmit Confidential Digital Data. The Receiving Party keeps Confidential Digital Data strictly confidential and does not disclose it to any other persons. The receiving Party may disclose Confidential Digital Data as required by law or court order, including a subpoena or other form of compulsory legal process issued by a court or governmental entity. The receiving Party may also disclose the Confidential Digital Data to its employees, consultants or contractors in order to perform services or work solely and exclusively for the Project, provided those employees, consultants and contractors are subject to the restrictions on the disclosure and use of Confidential Digital Data.

6 CONCLUSION

The thesis deals with procurement utilizing building information modeling in civil construction. The aims of the thesis are creation of procurement documentation and its content, which is necessary for using the building information modeling method in civil engineering projects and also BIM protocol structure development based on the experience of various countries.

The first chapter was focused on the theoretical foundations regarding Building Information Modelling (BIM). This chapter define the definition of Building Information Modelling (BIM) and also describes the main benefits that the using of BIM method brings with it. In addition, this chapter discusses such terms as Level of Development, Level of Definition and Level of Information need, and also describe the difference and their relation to each other. Theoretical review was developed based on the Czech and foreign information sources. Thus, the first established objective of this master thesis was fulfilled.

The second chapter was devoted to the analysis of established BIM standards for civil engineering in various countries, which was the following established objective of the thesis. There were analyzed the standards of such countries as UK, USA, CR, Russia and Singapore. It was discovered that changing laws and making amendments is a long and laborious process, therefore, according to the concept, the best solution in this case is to establish the necessary rules in the form of technical regulations that can develop faster.

Based on the foregoing, further in the thesis were considered technical regulations, namely the function and content of such technical regulations as the BIM Protocol, BIM Execution Plan, Common Data Environment requirements and data standard requirements. Thus, the third established objective of this master thesis was fulfilled.

The next chapter of the thesis was devoted to the analysis of the BIM Uses and has not only theoretical but also practical significance. The chapter described such term as the BIM Use, the existing classifications of these Uses, as well as the method of their evaluation. The practical significance of this chapter was a comparison of the BIM Uses from various sources in accordance with the individual phases of the construction project, in which not only the number of BIM Uses were compared, but also the BIM Uses itself. Due to the country permitting process specifics different sources have different vision for the number and content of the project phases and because of this, some project phases needed to be combined for BIM Uses comparison.

In accordance with the comparison results, it can be said that the number of BIM Uses defined by the buildingSMART and the BIM Execution Planning Guide was approximately the same in terms of content and quantity. The number of BIM Uses defined by CAS, in turn, exceeded the number of BIM Uses defined by buildingSMART and BIM Execution Planning Guide by almost two and sometimes three times. For the most part this was due to the fact that some BIM Uses were divided by CAS in more detail into several BIM Uses. Some BIM Uses defined by CAS were completely different and were not observed as part of BIM Uses from other sources.

The last part of the thesis was devoted to the development of a BIM protocol based on experience and existing protocols in various countries. The BIM Protocol is a standardized legal agreement, which establishes additional obligations and rights between employer and project team member and can be incorporated into construction contracts with a simple amendment. The developed protocol includes such parts as the definitions, project information, key project contacts, obligations of the employer, obligations of the project team member, risk allocation, property rights and the electronic data exchange. Thus, the last established objective of this master thesis has been fulfilled.

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LIST OF ABBREVIATIONS

AEC	Architecture, Engineering and Construction
AIA	American Institute of Architects
BEP	BIM Execution Plan
BIM	Building Information Modelling
BS	British Standards
BSI	British Standards Institution
EIR	Employer's Information Requirements
CAD	Computer Aided Design
CAPEX	Capital Expenditures
CAS	Czech Agency Standardization
CDE	Common Data Environment
CIC	Construction Industry Council
COBie	Industry Foundation Class
CoP	Code of Practice
CR	Czech Republic
DMS	Data Management System
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
GOST	Gosudarstvennyy Standard (State Standard)
IFC	Construction Operations Building Information Exchange
ISO	International Organization for Standardization
IoT	Internet of Things
IT	Information Technology
LIDAR	Light Detecting and Ranging
LOD	Level of Development / Level of Definition / Level of Detail
LOIN	Level of Information Need
NBIMS-US	National BIM Standard-United States
NBS	National British Standard
PAS	Publicly Available Specifications
PIM	Project Information Model

PIP	Project Implementation Plan
RIBA	Royal Institute of British Architects
SFTI	State Fund for Transport Infrastructure
SP	Svod Pravil (Code of Practice)
UK	United Kingdom
USA	United States of America
WIP	Work in Progress
2D	two-dimensional
3D	three-dimensional

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