UNIVERSITY OF MARIBOR
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USAGE, POTENTIALS AND CHALLENGES OF BUILDING INFORMATION MODELLING (BIM) IN SLOVENIA, AUSTRIA, GERMANY AND SWITZERLAND

Master thesis

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Uporaba, potenciali in izzivi informacijskega modeliranja gradenj (BIM) v Sloveniji, Avstriji, Nemčiji in Švici

Ključne besede: gradbeništvo, BIM, Informacijsko modeliranje gradenj, BIM metrike

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Povzetek

V magistrski nalogi so predstavljeni glavni potenciali in izzivi ter uporaba informacijskega modeliranja gradenj (angl. BIM – Building Information Modelling) v Sloveniji, Avstriji, Nemčiji in Švici, kot tudi sprejemanje Informacijskega modeliranja gradenj (BIM-a), saj je BIM trenutno v gradbeništvu ena najbolj publiciranih tem.

Raziskava je temeljila na vprašalniku, ki je bil skrbno zasnovan na HSLU (Hochschule Luzern) v Švici. Vprašalnik je bil v zaključni fazi sooblikovan s strani slovenskih partnerjev. S pomočjo rezultatov vprašalnika smo ugotovili, kakšna je dejanska uporaba in sprejetost BIM-a med vsemi akterji v procesu gradnje.

Usage, Potentials and Challenges of Building Information Modelling in Slovenia, Austria, Germany and Switzerland

Key words: civil engineering, BIM, Building Information Modelling, BIM metrics

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Abstract

In the master's thesis, the main potentials, challenges and usage of Information Building Modelling (BIM) in Slovenia, Austria, Germany and Switzerland are presented, including its, because BIM is currently the most widely discussed topic in civil engineering.

The study was based on a questionnaire that was carefully created at the HSLU (Hochschule Luzern) in Switzerland. We participated in the last phases of its development. . With the help of the results of the questionnaire, we evaluated the current usage and acceptance of BIM among all participants in the building process.

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USED SYMBOLS

ρ - Spearman rank correlation

d_i - the difference between the ranks of corresponding values

n - number of values in each data set

USED ACRONYMS

BIM- Building information modelling

DACH – Germany, Austria and Switzerland

DACH + SI – Germany, Austria, Switzerland and Slovenia

IFC - Industry Foundation Classes

bSDD - Building Smart Data Dictionary

IFD - International Framework for Dictionaries

IDM - Information Delivery Manual

MVD - Model View Definition

BCF - Open BIM Collaboration Format

1 INTRODUCTION

1.1 Description of the problem

Civil engineering is one of the oldest and most important disciplines of human culture. It is responsible for design, construction and maintenance of buildings, bridges, dams, tunnels, roads, etc. Throughout history, a lot of magnificent buildings, bridges and towers were built with a great deal of knowledge by civil engineers, from the classical work that can still be admired after so many years, for instance Partheon in Greece, Great Wall of China in China, aqueduct in Roman Empire, largest Maya city of Chichen Itza in Mexico, amphitheatre Colosseum in Rome, Italy, Taj Mahal in India, to modern work, built in the last decades, such as Millau Viaduct in France, The Bailong Elevator in China, Beijing National Stadium in China, Burj Khalifa in Dubai, Danyang – Kunshan Grand Bridge in China, Palm Islands in Dubai and so on. Therefore, we can say that civil engineering is a magnificent discipline, which is creating admirable objects and is surprising us repeatedly. However, if we compare civil engineering with any other industry, for example with automotive industry or mechanical engineering, we can see that civil engineering is lacking innovation, it is not really open for new methods, new knowledge, new ideas. Researches showed that the main reasons for this include the costs required to successfully implement BIM, the lack of competence, resistance to change and so on. Slowly, this situation is changing; new technologies and methods are slowly being implemented in companies, organizations, teams and are creating even better results.

Currently, the most popular and discussed topic and concept in civil engineering is Building Information Modelling (BIM), which is the main topic of this master thesis.

1.2 Goals and limits

In the master thesis, we presented the BIM metrics, discussed the BIM implementation in companies, organizations and teams in various European countries and presented some models

for measuring the BIM implementation, maturity and readiness. The goal of the master thesis was also to focus on potentials and implementation of BIM in Slovenia, Austria, Germany and Switzerland and evaluate them with the help of a questionnaire. To achieve this, statistical methods were used.

The aim of this master thesis was to make a comparison study of the BIM implementation in Slovenia, Austria, Germany and Switzerland and to evaluate the current level of the BIM implementation in those countries. The second aim of the thesis was to examine the factors that were important for the evaluation of the results. Those were:

- age of civil engineers,
- company size,
- project volume
- BIM knowledge and implementation in the company.

The scope of the research was to examine architecture construction engineering (AEC) with a special focus on construction companies, where we studied the engineers' usage of BIM. Within the research and based on the hypotheses, we separated companies on the side, small and large companies, where large companies are considered as the companies with more than 49 employees and small companies with up to 49 employees.

1.3 Goals and limits

Hypotheses are related to the three parts of thesis results:

1. Statistical analysis using Spearman's rank correlation and verification of hypothesis for Slovenia. The hypotheses were as follows:
    - In the companies in which new methods were implemented digitalization created new income.
    - The usage of BIM is higher among younger engineers.
    - Large companies operate with more BIM projects.
    - Companies who anchored the digitalization are also using BIM.
    - The more often that companies use BIM, the lower are the costs.
    - More than half of Slovenian companies are currently in the BIM Level 2.
2. Statistical analysis using Spearman's rank correlation, verification of hypotheses for the DACH region and comparison of results with Slovenia. The hypotheses for the DACH region were:

- In the companies in which new methods were implemented, digitalization created new income.
- The usage of BIM is higher among younger engineers.
- Large companies operate with more BIM projects.
- Companies who anchored the digitalization are also using BIM.
- The more often that companies use BIM, the lower are the costs.
- More than half of the companies in the DACH region are currently in BIM Level 2.

3. Verification of results with expert interviews

1.4 Key findings

Within the research, based on the questionnaire and expert interviews, we were able to conclude the following:

- BIM implementation does not have a big influence on the costs.
- Younger civil engineers tend to know BIM better than older civil engineers in Slovenia and Austria and vice versa in Switzerland and Germany.
- A number of projects in which BIM is the main model does not correlate with the size of those projects.
- Large companies tend to use BIM in projects more often because the implementation of BIM is easier from the resources point of view.
- In the Slovenian companies in which the digitalisation is anchored BIM is used more often.
- The BIM level in the DACH region varies between BIM Level 1 and BIM Level 3, where small companies are mostly in BIM Level 1 and large companies in BIM Level 3.
- The average BIM Level in Slovenia is 2.

2 BIM METRICS

2.1 BIM: Introduction

Building Information Modelling is currently very popular synchronism among civil engineers, architects, project developers and others, but BIM is not new. The beginner of BIM was Douglas Engelbart in 1962, who wrote the article "Augmenting Human Intellect: A Conceptual Framework", in which he described a concept that was very similar to modern parametric modelling (What is Building Information Modelling, 2016). Since then, BIM had its ups and downs in development, but has finally become the main topic and is drastically evolving. Until today, different definitions of BIM have developed, but all of them share a common idea of what is the purpose of BIM. The main goal of BIM planning methods is to develop a common information model where all stakeholders are able to participate, change certain parts of model, view all changes close to real-time, coordinate activities through BIM model and work towards the ideal final product built as-planned and with lower costs and faster compared to non-BIM (CAD) approach.

2.2 BIM implementation

We want to evaluate current position of BIM in a company, team, organization or country. Therefore, the need for metrics, with which we could evaluate this position, is necessary. With this we can measure successes or failures in projects, teams, organizations, etc. and determine improvements with which we can lower costs, improve efficiency, fasten the work, achieve better financial investments and other. This means, that metrics need to be accurate, reliable, easy to use and they need to be enough flexible so they can adapt to different business models and organizational sizes of different companies, etc. To increase these specifications of metrics, we need to obtain set of guiding principles that are: accurate, applicable, attainable, consistent, cumulative, flexible, informative, neutral, specific and usable (Succar, 2010). Until today different software and guidelines for BIM were developed, which are making inexperienced users even less productive. For successful implementation of BIM, every user must understand BIM concepts and be able to collaborate with other participants. If not, work is less productive, risks arise, errors occur, problems start to pile up and project costs drastically increase while

satisfaction, success and efficiency drastically decrease and problems in BIM implementation are inevitable. Over the years, many approaches, technologies, recommendations, strategies and BIM implementations were developed, but widespread uptake of BIM and lack of systematics lead to risks and challenges that are lowering its effectiveness. The biggest challenge nowadays is evaluating the uptake of BIM. Because of that, the question "What is the most appropriate method to measure BIM implementation?" is very relevant. This question is not yet completely answered since we need to develop a standard method to measure different implementations of BIM comparing efficiency gains. With this standard method, stakeholders would be able to decide what are the most appropriate strategies for them (Succar, 2010).

Over the years different authors designed some approaches with which companies, teams and organizations should be able to measure their failure and success. One of the most active in this area is Bilal *Succar* (Succar, 2012) who thought about the fact, that BIM metrics should measure performance and should as well be accurate and able to adapt to different organizations. Therefore, based on the international guidelines, *Succar* developed the *Five components of BIM performance measurement* (Succar, 2010). The framework consists of different high – level concepts that generate guides and tools to facilitate BIM implementation, conduct BIM performance assessments and generate multi-tiered educational curricula. Five components of BIM performance measurement include BIM capability stages, BIM maturity levels, BIM competency sets, organizational scales and granularity levels (Succar, 2012).

2.2.1 BIM capability stages

BIM capability is an actual implementation of BIM tools and protocols in a certain organization that serve their purpose and their ability to generate a product or deliver an outcome (BIM metrics). Therefore, BIM capability stages define the minimum BIM requirements that need to be achieved by a certain team/organization when they implement BIM. These stages are: *BIM stage 1 (object-based modelling), BIM stage 2 (model-based collaboration)* and *BIM stage 3 (network-based integration)* and are shown in Figure 1 (Succar, 2012).

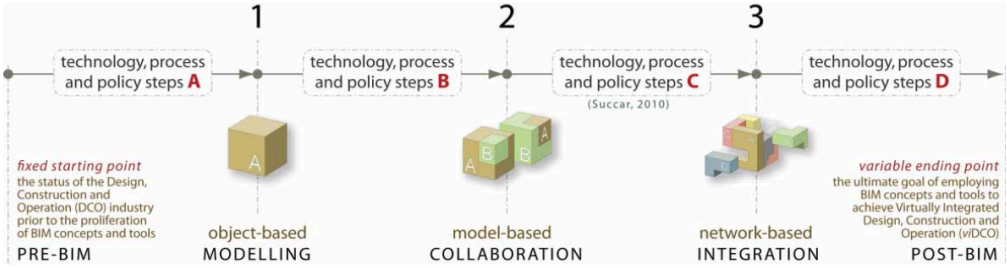

Figure 1: Step sets *(Succar, 2012, pg. 125)*

2.2.2 BIM maturity levels

With BIM maturity we determine the degree of success of BIM implementation in order to present benchmarks for improvements of current development and implementation of BIM in a team, organization or country. To achieve this, BIM maturity index was developed (*BIMMI)*, which consists of five distinct levels: *initial ad hoc, defined, managed, integrated* and *optimized* as seen in Figure 2 (Succar, 2012).

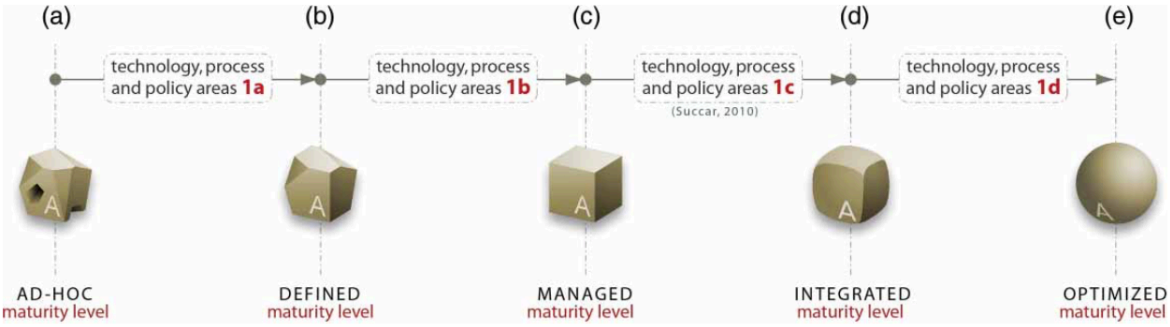

Figure 2: BIM maturity levels at BIM stage 1 (Succar, 2012, pg. 133)

2.2.3 BIM competency sets

A BIM competency set is a hierarchical collection of individual competencies identified for the purposes of implementing and assessing BIM. The term competency refers to the abilities that are suitable for implementing and assessing BIM capability as well as maturity (Succar, 2012).

2.2.4 BIM organizational scales

The organizational scale was developed in order to allow BIM performance assessments to take into account the diversity of markets, company sizes and their disciplines (Succar, 2012).

2.2.5 BIM granularity levels

With granularity levels (*level 1, level 2, level 3* and *level 4*), we can increase the flexibility of the maturity assessments and enhance the BIM capability. With higher granularity levels (*level 3* and *level 4*), we achieve more detailed competency areas and with lower granularity levels (*level 1* and *level 2*), competency areas are less detailed.

Performance assessments can be conducted involving these *five components* (BIM capability stages, granularity levels, organizational stages, competency sets and maturity levels). Guidelines in form of a figure, shown in Figure 3 (Succar, 2012), present steps that are needed to generate the appropriate assessment reports (Succar, 2012).

Figure 3: BIM capability and maturity assessment (Succar, 2012, p. 139)

Since these methods evaluate the BIM maturity effectively but do not address the success of the BIM projects quantitatively, *Succar and others* improved the methodology for macro-BIM adoption assessment and planning with five new adoption models, matrices and charts (areas of diffusion assessment and planning, macro components and milestones for assessing and comparing the BIM maturity of countries, macro-dynamics, approaches and actions for accessing, comparing and planning adoption policies across markets and groups of macro-diffusion responsibilities roles), which are closely presented in subchapter BIM implementation phases and adoption models.

2.3 BIM implementation phases and adoption models

BIM implementation phases are BIM readiness, BIM capability and BIM maturity.

BIM readiness represents the willingness of a company, organization or team to adopt BIM approach and its tools, protocols, etc. for that; BIM levels have become the main definition of the criteria that need to be fulfilled (Succar, 2010). BIM levels are *level 0 BIM, level 1 BIM, level 2 BIM, level 3 BIM* and *level 4 BIM and beyond*. With these levels, we are able to determine the actual readiness of a certain country, company, team, etc. for BIM and the the requirements to progress into the next BIM level. This may be confusing for new adopters of

BIM because in most cases, people think that all BIM levels are the same. In Figure 4, the main idea of BIM levels is presented.

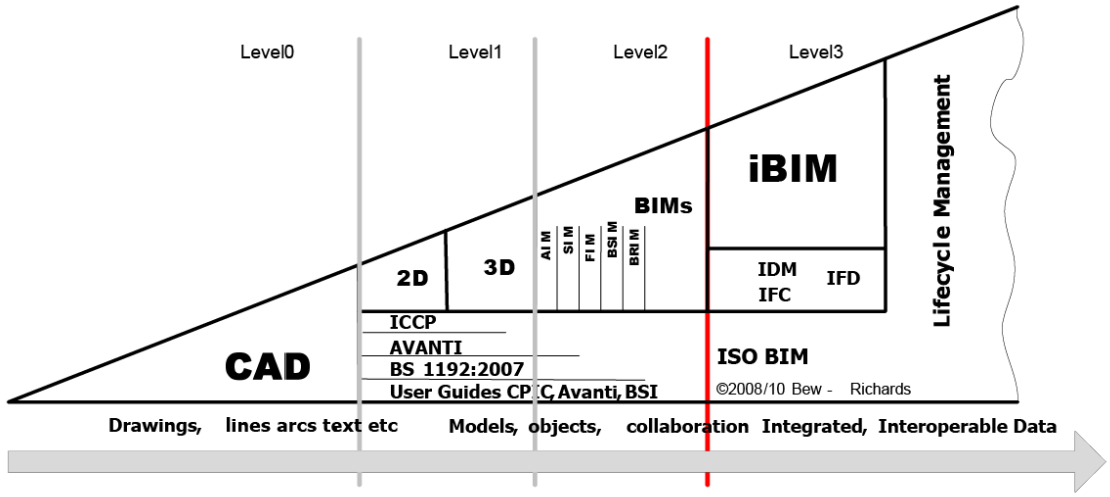

Figure 4: BIM levels (The BIM hub, 2016)

- *Level 0 BIM* is the simplest form of BIM, where only 2D CAD software is used to create paper printed outputs. On this level, there is no collaboration between different participants. Until today, most of the companies have outgrown this BIM level.
- *Level 1 BIM* is a level where contribution between 3D CAD and 2D is in front. On this level, conceptual designs are made with 3D CAD and other phases of projects are made in 2D CAD. Unfortunately, this is the level in which most of the companies are still mainly operating.
- *Level 2 BIM* is the level where the most important criteria are collaborating between all parties. The idea of *Level 2* BIM is for all parties to communicate and distribute information through the common file format and therefore combine data with their own to create a common BIM model, where errors and incompatibilities are eliminated. Unfortunately, most of the companies are still far behind this level, but the changes are slowly occurring and companies are slowly approaching this level.
- *Level 3 BIM* is a level where full collaboration between all parties is created on a common model. This model enables everyone to access and modify it, it allows for the changes to serve as propaganda to all project members. Therefore, in this model, all parties are informed about the changes and most recent information; it also helps to minimize conflicts.

- *Level 4 BIM and beyond*: the main idea for the future is to create common models that will also contain time analysis, cost management and facilities managements, but to get there, we still have to do a lot of work, educate and inspire others to pursue this goal (BIM levels explained, 2014).

BIM capability represents the actual implementation of BIM tools and its protocols in a specific organization. Developed capability stages are *BIM capability stage 1, BIM capability stage 2* and *BIM capability stage 3*. With capability stages, we can identify the minimum requirements needed to implement BIM concepts in a certain organization, team, or company. However, it is impossible to determine their success in creating BIM models or how those models are developed, therefore we need maturity levels because we can measure and improve BIM abilities with them (Succar, 2010). For BIM maturity, see chapter BIM implementation.

BIM implementation phases, described above, are presented in the Point of Adoption. With the Point of Adoption, we identify the most important step in a company's or team's organization where the transformation from readiness to capability and maturity is made. Therefore, many models have been developed until today to measure how adoption occurs within the company, team, etc., but unfortunately, not all of those models are suitable for every company, organization and team because of their diversity. However, *Succar and Kassem* made a research, taking into account that the most important property of such models is that they are able to adjust to different strategies and organizational features, and developed *five BIM adjustable models* that are enough flexible, usable and, what is most important, they generate results that are applicable exclusively to BIM adoption at the macro cluster (includes macro subdivisions, sectors, industries and specialties) (Succar, 2010). Five BIM adjustable models by *Succar (Succar, 2016)* are 'Diffusion areas model, Macro maturity components model, Macro diffusion dynamics model, Policy actions model and Macro diffusion responsibility model'. The research is still in progress and will be applied to different countries to improve and acknowledge those models (Succar, 2016).

2.3.1 Diffusion areas model

With diffusion areas model we can clarify how field types of BIM interact with its capability stages by generating nine diffusion areas, shown in Figure 5. Diffusion areas can be evaluated separately or collectively. The main advantage of diffusion areas model is its ability to generate targeted rating to analyse and compare market (Succar, 2016).

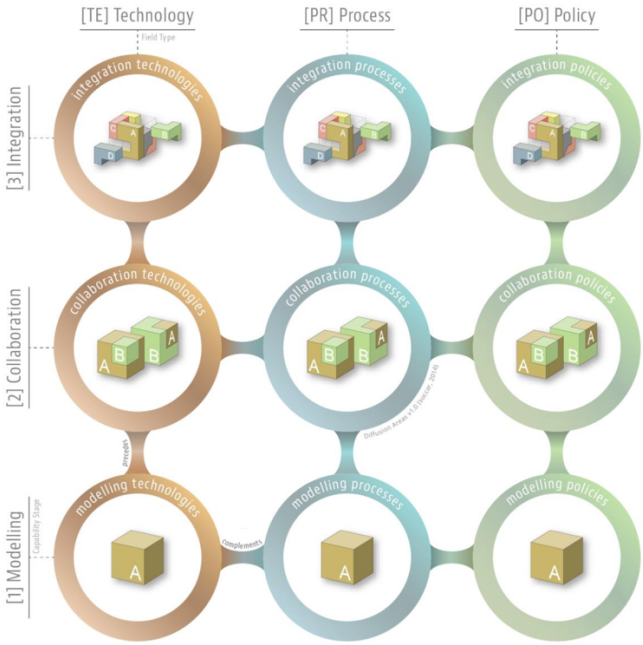

Figure 5: Diffusion areas model (Succar, 2016, p.68)

2.3.2 Macro maturity components model

With macro maturity model, we can identify eight complementary components to measure and establish BIM maturity of a country, organization, team, etc. Complementary components are 'objectives, stages and milestones, champions and drivers, regulatory framework, noteworthy publications, learning and education, measurements and benchmarks, standardized parts and deliverables, and technology infrastructure'. Each maturity component can be presented within five maturity levels: *Ad-hoc or low maturity, Defined or medium-low maturity; Managed or medium maturity; Integrated or medium-high maturity; and Optimized or high maturity*. When we evaluate each maturity component, we can learn what is the exact maturity of a certain country, organization, etc. and can also easily compare model results with other countries, organizations, etc. The results are presented in Figure 6 (Succar, 2010).

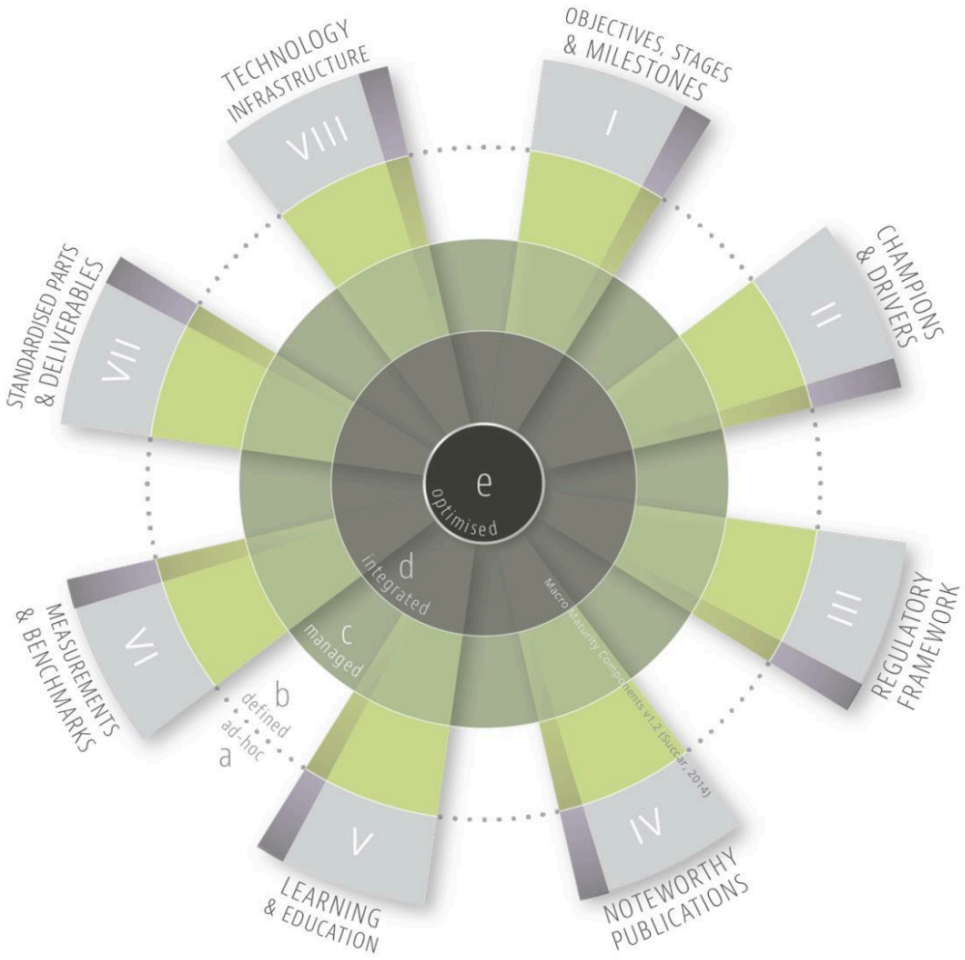

Figure 6: Macro Maturity Components model (Succar, 2016, p.70)

2.3.3 Macro diffusion dynamics model

With macro diffusion dynamics model we can identify three different diffusion dynamics: *top-down, bottom-up* and *middle-out.* Therefore, we can clearly understand from where and how diffusion starts and how it unfolds within a population. These three diffusion dynamics allow horizontal and vertical mechanics as well as a combination of isomorphic pressures: *coercive, mimetic* and *normative*, therefore innovation can easily and continuously pass from "transmitters" to adopters (Succar, 2010). Macro diffusion dynamics model and its dynamics are shown in Figure 7.

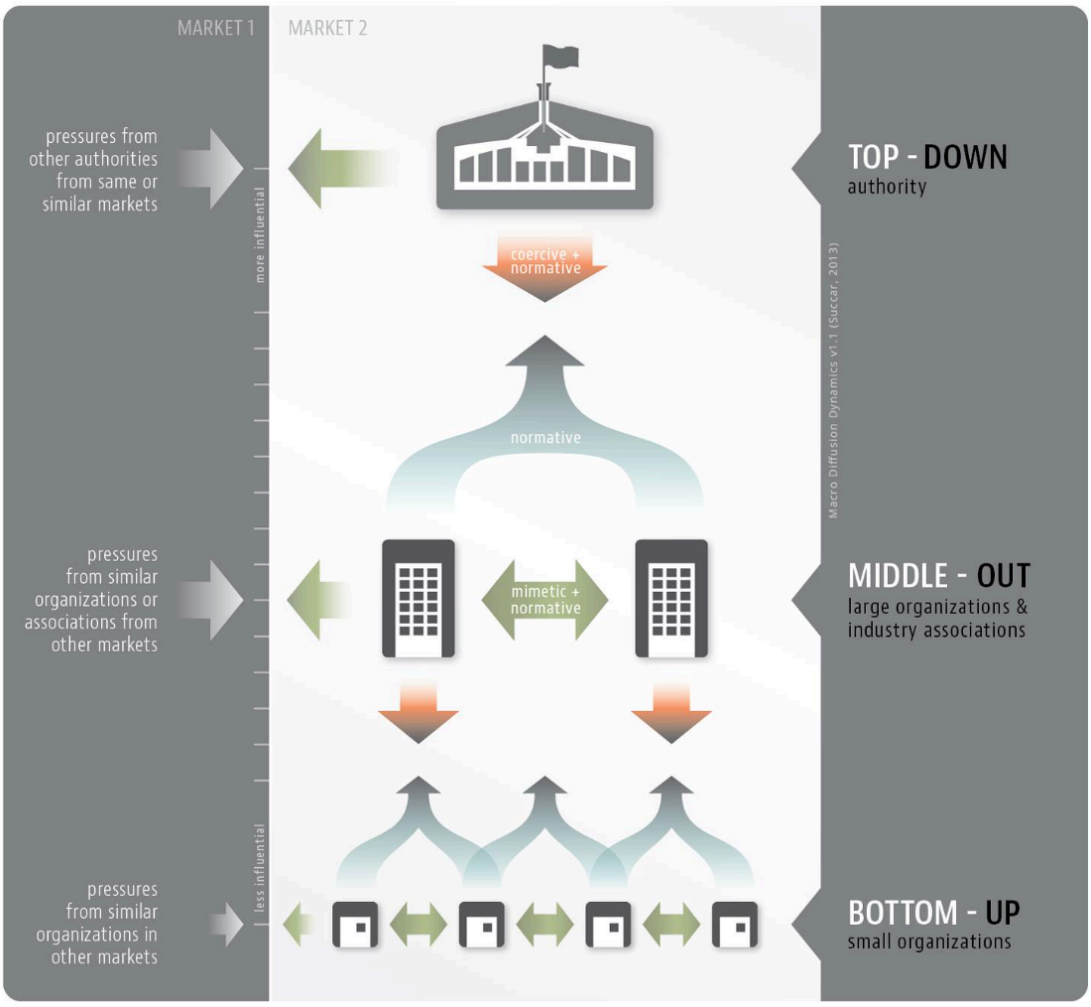

Figure 7: Macro diffusion dynamics model (Succar, 2016, p.72)

With the three dynamics we can identify how adoption decisions, made by one player, can influence the adoption decision of other players (Succar, 2010).

2.3.4 Policy actions model

Since policy makers could affect the adoption of innovative solutions, it is not necessary that they will encourage implementation or speed up diffusion. Therefore, policy actions model was developed to focus on the actions that policy makers take to influence certain adoption of innovative process on the market. This model identifies three implementation activities: *communicate, engage* and *monitor*, which is in correlation with the implementation approaches: *passive, active* and *assertive*. This way, we can generate nine policy actions, shown in Figure 8 to determine the relation between all nine actions (Succar, 2010).

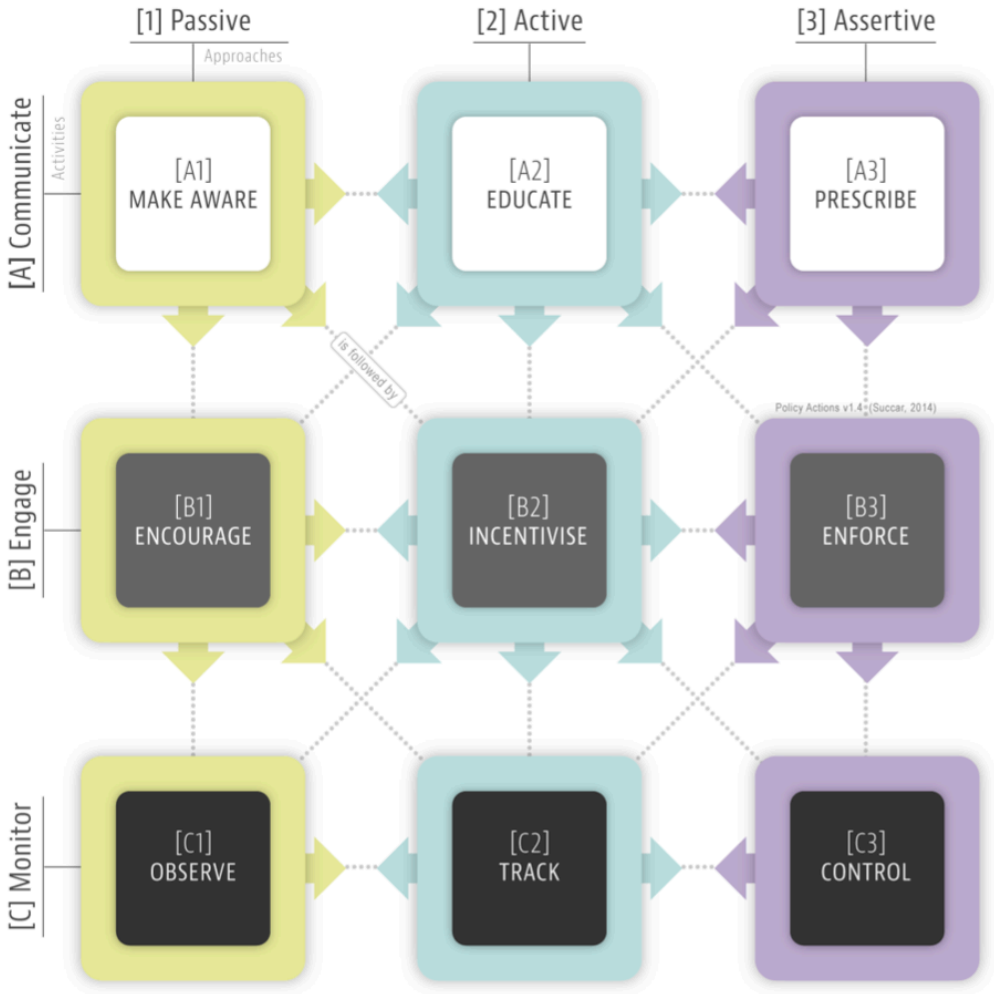

Figure 8: Policy actions model (Succar, 2016, p.73)

With this model, we can increase the intensity of a policy maker's involvement in BIM adoption from passive to assertive behaviour as well as determine benefits or necessity of a new process or system, represent progression, evaluate adoption behaviours, challenges and outcomes (Succar, 2016).

2.3.5 Macro diffusion players model

Macro diffusion players model was created to analyse BIM diffusion within the roles that are played by industry stakeholders. To create the model, we need to identify nine BIM player types that are distributed across BIM fields, those macro diffusion players are: *authorities*, *construction organizations*, *software developers*, *educational institutions*, *individuals*, *value – adding resellers*, *industry associations*, *communities of practice* and *technology advocates* as seen in Figure 9 (Succar, 2016).

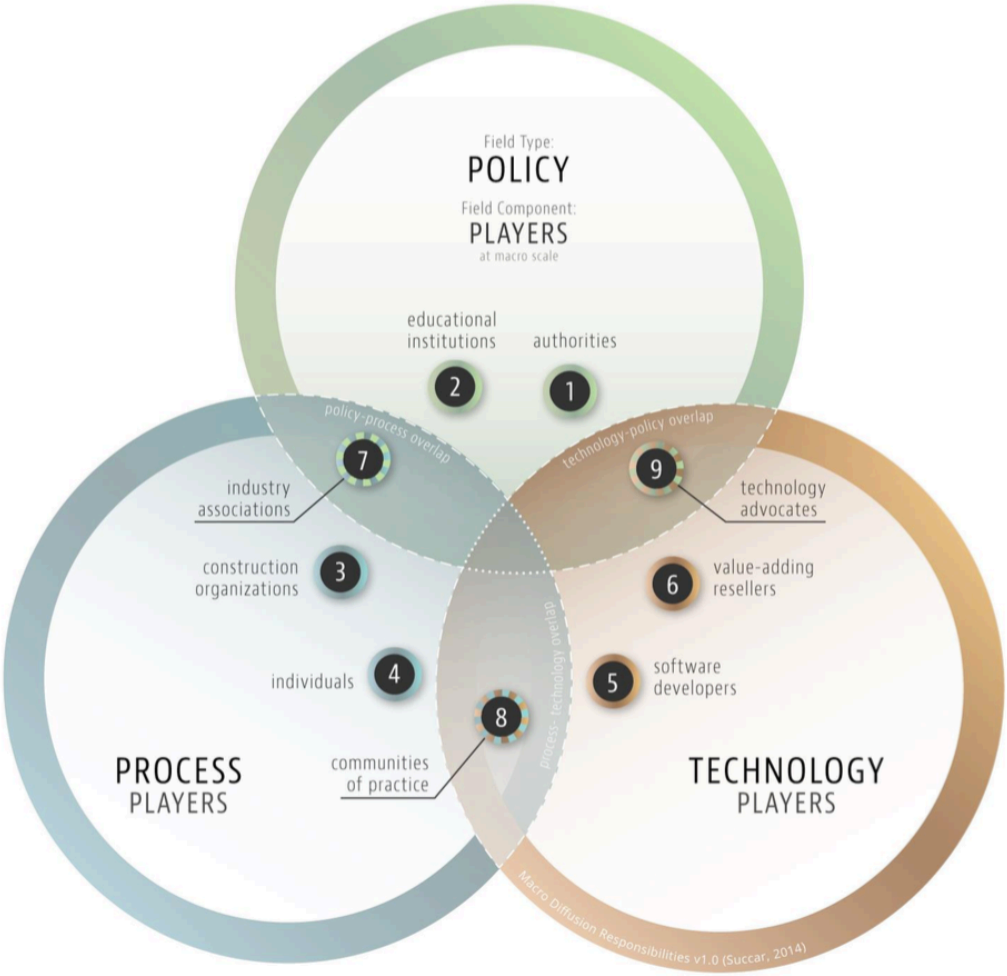

Figure 9: Macro diffusion players model (Succar, 2016, p.76)

With this model, we can conduct different assessment activities, such as Isolate BIM players by their group and analyse their BIM diffusion activities, compare the BIM diffusion activities of one player group to other groups within the same market and Compare the BIM diffusion activities of players pertaining to the same group across different markets (Succar, 2016*)*.

2.4 BIM benchmarking

As we have already written, there exist several definitions of BIM performance. On the one hand, many companies are deciding to implement BIM because of its benefits and on the other hand, a lot of companies are afraid to implement it due to difficulties in deciding for the most appropriate organizational and technical approaches. The reason for this could be the lack of guidance in identifying and prioritizing their respective requirements. The gap between the

expected benefits and the unforeseen requirements increases the risks, costs and difficulties regarding BIM implementation. Until now, several tools, concepts and technologies have been developed worldwide with a purpose of benchmarking the system that uses BIM, such as *BIM Meetlat* (BIM measure indicator) by BouwnD, *BIM Successpredicto*r by DeBIMspecialist, *BIM Succesvoorspellers* (BIM success forecasters) by Gobar in the Netherlands, assessment tools such as *BIM maturity index* (BIMMI), *the national BIM standard* (NBIMS) in the USA, *BIM capability stages* and so on. However, the biggest problem is that there is no common benchmarking system for companies that use BIM in their projects (Sebastian, van Berlo, 2009). The problem with certain assessment tools is that they define minimum BIM requirements that need to be reached by a certain team, organization or company as it implements BIM concepts and technologies into their processes. The most commonly used assessment tool in the USA is NBIMS CMM, which was developed to assess BIM models. It is a matrix with 11 areas of interest on the x-axis and 10 levels of maturity on the y-axis (McCuen, Suermann, 2007). It was developed for evaluating practices and processes for BIM users, but it does not measure the BIM maturity of the organization. NBIMS CMM was adapted in the Netherlands as BIM Meetlat. However, there is no clear explanation how the original tool, which was developed for American context, was adjusted to the Dutch contest; the problem with adapting NBIMS CMM in the Netherlands is also not completely accurate, because the business processes and distribution roles in different countries may vary. An improvement of the several attempts to develop and adapt NBIMS CMM in the Netherlands was the so-called BIM Succesvoorspellers, where they assess both hard and soft aspects of BIM. The tool is still in the developing stage, however (Sebastian, van Berlo, 2009).

If we drew a conclusion, we could say that with the development of several different tools to measure the capacity and maturity of BIM, they, unfortunately, still have some weaknesses. For example, none of these tools can measure the BIM maturity of a model and also of organization. Also, none of this tools were used in the construction industry. Because there are still uncertainties in the implementation strategies and actual performance of BIM, *R. Sebastian* and *L. van Berlo* conducted a research to generate an instrument for benchmarking BIM performance, the so-called *BIM Quick Scan* tool. Within the research, they wanted to focus on developing a BIM benchmarking tool that could resolve the shortcomings of the existing assessment tools, therefore, they introduced a tool that can supposedly serve as a standard BIM benchmarking instrument in the Netherlands (Sebastian, van Berlo, 2009).

The research consisted of three steps: *development*, *practical verification* and *validation of the prototype tool*. To develop the tool correctly, they took into account Succars' (Succar, 2010) guiding principles to measure the specifics of BIM performance (Succar, 2010). BIM Quick Scan tool can be used to scan an organization through four chapters that represent hard and soft aspects of BIM: Chapter 1 (*organization and management*), Chapter 2 (*mentality and culture*), Chapter 3 (*information structure and information flow*) and Chapter 4 (*tools and applications*). The quantities are measured in the form of a multiple choices questionnaire where a total number of the criteria is limited to 50, to achieve a certain speed of a scan. Each "question" represents a KPI with a number of possible answers. For each answer, a certain score is assigned and each KPI is enriched with a certain weighting factor. The sum of all the scores (answers) with weighting factors represents the total score of BIM performance of an organization. The advantage of this tool is also that the questionnaire is supposed to be filled in by a BIM consultant who observes the organization and also makes an interview with a person who is in charge of BIM; with this, the misinterpretation of KPIs or the questions is avoided. After the analysis, an organization receives the results of the scan with a total score, which represents a certain level of BIM performance. What is more, the results are presented in a form of a radar graph as seen in Figure 10, where each chapter is visualized and the level of performance is related to different BIM aspects. With this sort of presentation, we can easily point out underperformance of particular aspects and put it into perspective. Organizations are also welcome to repeat the scan over time to monitor their own progress of the BIM performance, where the minimum interval between two assessments should be at least six months because of the required time for the adoption of new technologies and working methods. Their goal is for as many companies as possible to accept this tool in order to accelerate BIM innovation in the Netherlands. Furthermore, the idea is to make BIM Quick Scan tool available free of charge, so it would be better accepted among companies. The BIM Quick Scan tool is thus available on the homepage of the BIM Quick Scan tool (Sebastian, van Berlo, 2009).

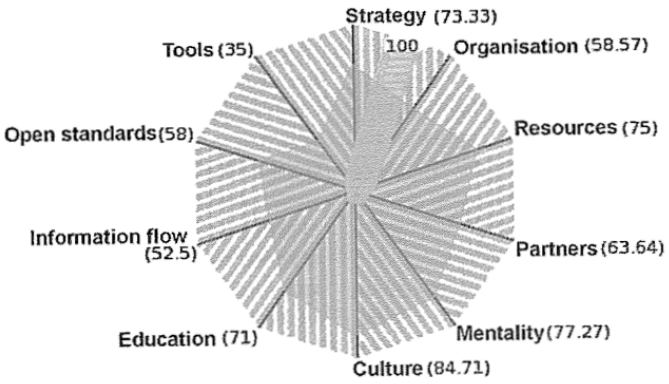

Figure 10: Mapping of the Quick Scan results in radar diagram (Sebastian, van Berlo, 2009, p.260)

The tool was also verified by 15 experts; to develop the accurate metrics is continuously being improved and is expected to be used in individual companies and the companies involved in project organizations. The advantage of the tool is also the possibility of comparing the results with other companies who did the scan for their performance. Lastly, experts are available to help with the scan and give support. However, the tool also has disadvantages because within the development of the tool, they did not provide appropriate metrics to measure the success or maturity levels of the BIM projects under review, and the tool is not exact in showing how successful a BIM project is, nor does it explain the relationship between the purposes of BIM implementation and the performance of a project (Won, Lee, 2015).

Because of the disadvantages and shortcomings of all developed tools and methods, which did not carefully consider whether the projects were successful or not before evaluating the maturity levels of those BIM projects, *Won* and *Lee* decided to make a study to investigate the applicability of a success level assessment model for the BIM projects, the so-called *SLAM BIM*. A goal-driven approach was developed with an assumption that the success of a project cannot be evaluated if we don't identify project goals at the beginning because the Key performance indicators (KPIs) can vary depending on project goals (Won, Lee, 2015). What was pointed out by this study is the providence of a tool that can evaluate whether a BIM project is successful. The tool was applied to two projects in North Korea to verify the applicability of a tool with different project characteristics and goals where BIM was implemented in preconstruction and construction phases. It measures the success of project goals which have to be defined first because they are not fixed and are varying according to the project (Won, Lee, 2015). The proper approach, developed in this study is as follows: firstly, it is necessary to identify the project goals because the project is successful if the goals are achieved. Secondly,

a set of KPIs needs to be identified depending on the goals. The method consists of five main steps which are: *BIM goal, BIM use, BIM KPI, Unit measurement* and *Collection form* and are shown in Figure 11.

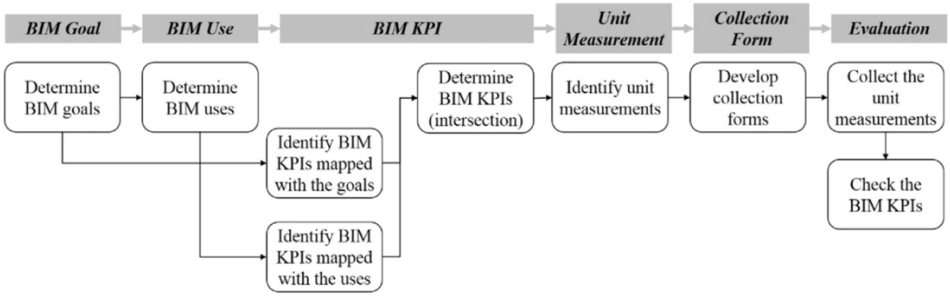

Figure 11: SLAM BIM process (Won, Lee, 2015, p.36)

In the first step, the *BIM goal*, we identify the project's goals. This step is important because the success of a project depends on whether its goals are achieved or not. As with any other project, not just a BIM project, we can say that a project is successful if the goals are achieved and it is unsuccessful if the goals are not accomplished. For the success of a project, it is also of a great value if goals are shared with project participants. In the second step, the *BIM use*, we determine the appropriate uses of BIM by considering defined goals. This is important because uses can help to achieve identified goals. Depending on the project participants and characteristics of a project, some uses are mandatory for every project and others are suggested or optional (Won, Lee, 2015). The next step is the *BIM KPI*, where we identify the projects' KPIs. With a KPI, we measure how close is the company to its strategic objectives (Won, Lee, 2015). In order to identify the appropriate KPIs, we have to first determine the candidate PIs (PIs for the goals and PIs for the use), then eliminate those PIs that are not in common with the PIs for the goals and the PIs for the use, as shown in Figure 12. Secondly, we make a list of the candidate KPIs. Those can change according to a project's characteristics. Because of that, the PIs should be able to measure the BIM performance of the project, meaning that we have to determine a set of the final KPIs by taking into account measurability, collectability and comparability of each PI. In the fourth step, the *Unit measurement*, we have to specify the unit measurement to measure the KPIs. Lastly, we have to collect the data from the construction site. In this final step, the *Collection form*, we should be able to collect the data in an uninvasive way, also the collection of the data should be integrated into the existing working processes (Won, Lee, 2015).

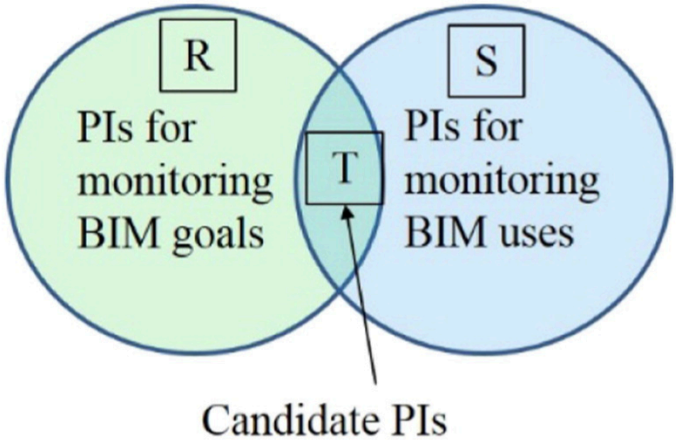

Figure 12: Identifying the projects' candidate PIs (Won, Lee, 2015, p.37)

For the case study, two BIM projects were taken into consideration. The first project was a parking garage, the predicted time for the construction of which was 10 months. The main frame of the construction was made of precast concrete. The goals of the project were to improve communication, improve work efficiency and technological capability. The second project was sports complex project, the predicted construction time of which was 11 months. The goals of this project were to improve communication, improve constructability and reduce the number of errors. Both projects had two goals in common, even though the lists of uses were similar. Within the evaluation of the tool, Won and Lee followed the before written steps, identified 10 candidate PIs for each project and then determined the final KPIs regarding the measurability, collectability and comparability of the candidate PIs. In the survey, 5 to 6 respondents participated in both projects, consisting of experts from a construction site and headquarters. The unit measurements were defined with the help of the interviews with the project participants. Both projects had 13 unit measurements to analyse the KPIs. To analyse the current work processes and measure the selected unit measurements, 9 data collection forms for the first project and 8 for the second project were developed. Most of the KPIs that were identified by SLAM BIM, were collected and analysed with the use of the proposed data collection forms and processes. However, within the evaluation of results, several KPIs were not utilized because of the problems with the data collection during or after the construction. Therefore, some BIM effects were not compared with past or current projects that were using traditional methods because of unstructured BIM processes or lack of the required support. Within the study, Won and Lee also examined the design errors and discovered that the most common errors are caused by the illogical design and were also the most common errors in both projects that were taken

into consideration. *Won* and *Lee* also measured and utilized the possibility of identifying errors without using BIM. For the second project they also collected the KPIs that were related to the change order, those were the number of change orders and the amount of change measured as charge order cost over total contract cost. The results showed that the change order caused schedule delays, additional costs and that the number of change orders were mostly caused because of the client requests. The biggest impact on the overall project costs was associated with civil engineers and architecture aspects. The study showed that response time has an enormous impact on schedule delays. In first project, the response time was fast enough (less than one week), therefore the project was completed on time, while in the second project, the response time was up to 15 weeks or more, which caused the delay in construction and the project was finished 3 months later as scheduled. The reason for such a long response time was too many change orders that were not been able to be followed (Won, Lee, 2015).

To sum up the main points of this survey, we can say that SLAM BIM can provide opportunities to continuously check and monitor the status of the BIM implementation during the design and construction phases. Design should be coordinated early in the project phase to prevent endless design changes during the construction and change orders and to efficiently manage the BIM models and processes. Historical data should be collected consistently to enable the comparison with a new collection of the BIM KPI between non-BIM and BIM projects. Furthermore, a proactive participation of the practitioners should be encouraged to align the BIM efforts and construction management mechanism, also project management information system should be designed in a way that it is able to support the BIM processes and automate the KPI data collection processes. The greatest disadvantage of this survey were the obstacles for a successful application of BIM because of the inefficient design change processes and BIM training programs. The limitations of this study were the lack of comparable data collected from the past projects that were using the traditional method and because participants did not have the means to collect relevant data before accomplishing the two pilot projects. Therefore, some KPIs were not compared between non-BIM and BIM projects. The forms also did not integrate with a project management information system (MIS), but *Won* and *Lee* are planning to develop a MIS in the future to minimize the efforts to collect and analyse data and to monitor the status of BIM implementation in real time (Won, Lee, 2015).

2.5 BIM benefits

As we know, the usage of BIM has many benefits. We know it is of great value to use BIM because we can optimize building solutions, reduce risks, limit errors, accelerate work, achieve better transparency and constant data update as well as better communication (Barlish, Sullivan, 2012). BIM helps us to reduce rework, improve productivity, reduce conflicts and changes during construction; it adds value to the civil engineering projects, etc. What is more, BIM also has great business benefits. From bringing new business to new clients, to new opportunities on the market, it also has a great impact on the overall project outcome, it can reduce errors in construction documents, it is also easier to identify problems earlier in the building process because of the virtual design and construction, it is a way to bring new offerings to an old business and it can reduce rework with fixing problems early, which means fewer issues in the plans and less errors on the construction site (Rodriguez, 2016). Stanford University's Centre for Integrated Facilities Engineering gathered the data on 32 major projects and discovered several BIM benefits. Those are: up to 40% elimination of unbudgeted change, cost estimation accuracy within 3% as compared to traditional estimates, up to 80% reduction in time taken to generate a cost estimate, a savings up to 10% of the contract value through clash detections and up to 7% reduction in project time. It is also believed among companies that using BIM increases their chances of winning projects, that BIM can also have some impact on their external project practices, that using BIM improves project outcomes and also has a very positive impact on a company's productivity (Azhar, 2011). But what we do not know are the benefits and outcomes of BIM usage for contractors, architects, engineers and owners. Therefore, we need to ask ourselves, what they will gain from using BIM on a project and how we can measure those benefits.

Until recently, there was no accepted calculation methodology and baseline to properly evaluate BIM's benefits, resulting in mixed perspectives and opinions of the benefits of BIM, causing confusion and general misunderstanding of expected outcomes. Furthermore, different definitions of BIM are causing confusion and different defining and quantifying of BIM is causing confusion in terms of BIM's benefits. This altogether causes for the determination of exact measurement for BIM's potentials to be difficult to develop. For example, for architects, the potentials of BIM potentials lie in coordination and productivity and for contractors this is scheduling and estimating, etc. What is more, the variety of projects makes it difficult to determine the uniform metrics to measure BIM benefits. We need the relevant methodology to

evaluate the expected benefits of BIM in any project, from a business point of view in connection with a valid baseline (Barlish, Sullivan, 2012). *Succar* believes that metrics should be easy to use, accurate, exact as well as able to adapt to different organizational sizes and industry sectors (Succar, 2012). In the past years, different framework calculation models to determine the value of BIM were developed, but they focus only on the general implementation and have varying nature. It is also a significant problem that owners have to decide whether to implement BIM or not, based on speculated benefits. What is more, in literature, the results of the researches and different approaches are not easily compared and it is difficult to use them. Therefore, *Barlish* and *Sullivan* decided for a case study approach to develop a more complete methodology to analyse the benefits of BIM and apply the recent projects to quantify outcomes with creating a more holistic framework of BIM and its impacts on projects' efficiency. The methodology was tested against three independent and separate cases. *They* said that the "BIM business case" should be established at the executive level, meaning it should contain both vocabulary and relevance to upper level management in a company as well as a plan for the implementation. *Barlish* and *Sullivan* empirically measured the data from the projects that were not using BIM and the projects using BIM to determine if the utilization of BIM can have any benefits in construction projects and in certain organization (Barlish, Sullivan, 2012).

Barlish and *Sullivan* analysed over 600 sources referring to the benefits derived from the BIM utilization to gather all possible information, knowledge and results for developing the exact method for measuring the BIM benefits. After a consistent analysis, they discovered that in many case studies, the terms »Key Performance Indicator (KPI)« and »productivity« were used, but were often not uniform across the case studies and not precise enough. Different models were also used in the case studies, such as *system dynamic modelling*, *lost productivity method,* etc., but they were used inconsistently across the case studies. Therefore, it is necessary to develop a framework methodology to quantify the benefits of employing BIM. *Barlish* and *Sullivan* did this by establishing the metrics to quantify the costs and benefits of BIM, testing the metrics on the case studies with the main focus on Non-BIM versus BIM projects in the same companies, evaluating the resulting information from the case studies and providing the conclusions from the data and validating the resultant framework model to evaluate benefit or loss from BIM (Barlish, Sullivan, 2012).

The framework development of their research is shown in Figure 13. The main purpose of the framework and case study was to provide the industry information on the benefits from the BIM

utilization and also to enable the comparison of benefits measured in other BIM related projects to build the business case for BIM utilization (Barlish, Sullivan, 2012).

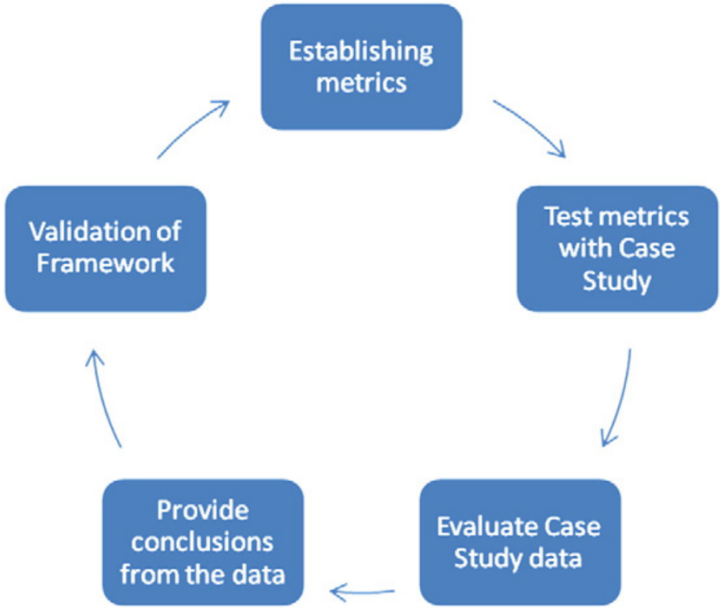

Figure 13: Framework development (Barlish, Sullivan, 2012, p.153)

The framework methodology is based on the consideration of money and management outcomes for the BIM implementation. In addition, general IT measurement processes were taken into account and are shown in Figure 14. As a result, value-based framework was proposed to analyse monetary outcomes. Within the research, organizational factors were taken into consideration and also BIM's resultant impact was analysed. For the case study, the comparison of the Non-BIM and BIM data sets was made to establish a basic methodology for the computation of the returns and investments of BIM (Barlish, Sullivan, 2012).

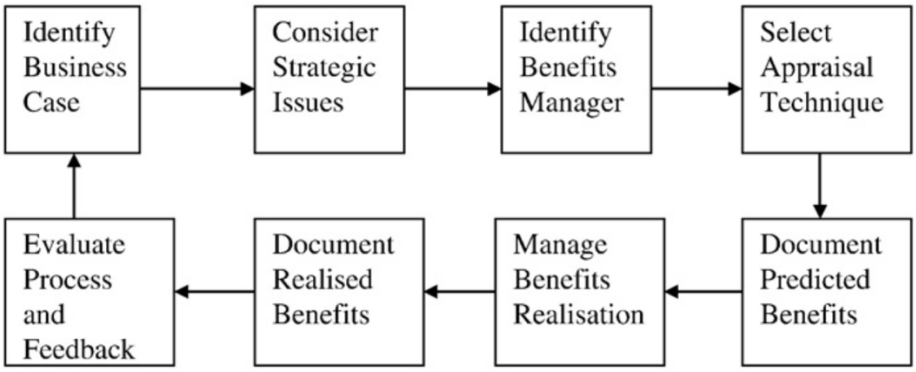

Figure 14: Process of measuring IT benefits (Barlish, Sullivan, 2012, p.154)

As a result of the research, a proper benefits analysis was made to measure returns and also calculate the investments required for BIM. From the matrix of potential benefits, it was determined that the most quantifiable returns are schedule, change orders and RFIs and investment metrics project costs and pilot costs that were divided into two groups: architectural and engineering costs and a 3D background model creator costs (Barlish, Sullivan, 2012).

Within the research, three cases were examined and determined: *returns*, *design and construction investment* and *area's returns and investments.* The returns were determined as a positive differential or a net gain from the BIM projects, design and in construction; the investments were established to get an insight into the investments or costs of BIM on a current project. The results showed that the costs are incurred due to the BIM design and that there are expected savings because of the BIM construction. Lastly, the area's returns and investments and analysis of returns the investments. This functional area is receiving the highest returns from change orders. It was established that BIM and its success depend on many factors, such as the size of a project, the team members' BIM proficiencies, communication of the project team and other organizational external factors, meaning that the success of BIM depends on the project and organization. Results showed that the calculated returns of change orders can present up to 42% savings of the standard costs in case 1 (returns), the RFIs can decrease up to 50% per tool or assembly, the duration reduction can bring a saving of 67% based on the standard duration. In case 2 (design and construction investment), the calculated investment can increase in design cost for architectural and engineering costs up to 31% and the 3D background model creator costs can increase up to 5%. Altogether, saving is in value up to 2%. In case 3 (area's returns and investments), in specific areas of semiconductor, manufacturing may have increasing returns comparing to a less complex area (Barlish, Sullivan, 2012).

In this research, a valid framework methodology and baseline were developed based on the application in one company, which presents a starting point for the stakeholders to begin their analysis. The methodology is strict for a stable environment and should be analysed further so it will be also suitable for projects and organizations that are exterior to this system. In addition, the proper baseline data on the non- BIM metrics must be obtained for a proper analysis of the BIM benefits (Barlish, Sullivan, 2012).

Because many mistakes are done by the site managers and inspectors while collecting and recording the progress of the site activities on the construction site and re-entering that information at the site office, different approaches on how to automate activities on the construction site were also made. With such an approach, we would be able to eliminate errors,

avoid delays, increase effectiveness and address costumers' and clients' concerns and requirements. The majority of construction delays are caused in the construction phase. Therefore, it is of a great value to control construction site operations with implementing BIM into daily construction operations because we can overcome the problems related to the traditional disputes and mistrust among the supply chain actors and also improve productivity and avoid the loss of information. Researches and approaches such as *Augmented reality*, *Radio frequency identification*, *3D Laser Scanning* and *Wireless sensor network* were developed with the purpose of automating the monitoring and checking processes of the construction site activities on the basis of zero or minimal human intervention (Omar, 2015).

The *Augmented reality* (AR) automatically updates the site activities to detect the differences between the design and the actual construction. It is an interface that overlays the digital information and presents it to the user's view and it is spatially aligned to the current physical environment. In this method, cameras are used to capture real current physical environment, after which the information is sent in a form of pictures through the PDA devices on the server that is connected to the office. The challenges of this method include camera difficulties in detecting the indoor objects when the light is weak, difficulties with comparing pictures of the state of a site because of the unclear pictures, covered items,while poor GPS signal can cause errors in the size by centimetres or even metres, etc. *3D Radio frequency identification (RFI)* is a wireless technology that is capable of automatic identification of objects and people based on the tags. The tags have a small antenna that can transmit the information through the radio frequency. The cons of this method are that the tagged objects must be unique to avoid any data mix and misleading results and all activities within the construction site should be covered with a network of RFID readers in order to collect the data from the objects and send this data to a database system that can translate these codes to activities. The method was to be integrated by several experts with BIM for an automatic update of the site activities. However, the downside of this method is that the entire site should be covered with the RFID readers in order to collect data from the tagged objects. In addition, any damage on the tags causes the impossibility of collecting data and transferring it. *3D Laser scanning (LS)* is a semi-automated process and is currently the most recognized 3D reality capturing method in the construction industry. With a high-end laser scanner and reflectors, we capture data from the site and build an as-built model with an accuracy of 3 to 6 mm. Because there are always many similar objects on the construction site, a 3D as-built model is manually entered into the system to avoid misidentification of similar objects. In the second stage of the process, the as-built model is

compared with the planned progress model (4D BIM). The challenges of this process are the following:laser scanning faces can detect only the exposed objects and activities, the data collection process is time-consuming and requires experienced surveyors, the scanning range is limited with the object's surface degree of reflectivity, the angle of measurements, sensor calibration, weather conditions (adverse weather prevents the scanning process), and a lot of manual effort is needed because of the lacking recognition of the objects with self-similarities. The *Wireless sensor network (WSN)* is another technology that is using sensor nodes that communicate with each other wirelessly to collect data from the surroundings and share it with a model. The method allows us to see the percentage of the completed tasks in a 4D model. The challenges of the method are the price, the need for experts to work with the technology, the quality of the transferred data depends on the Wi–Fi connection and the high ambient temperature has a negative effect on the sensors' performance. The study made at the Washington University also showed that the data collected with the WSN are unreliable. As we can see, the problem with these approaches and methods is that they did not meet the expectations and they also have many challenges and limitations. Therefore, *Omar* and *Dulaimi* conducted a new research and proposed a new prototype with which automation would be easier, more effective and error free. The proposed prototype consists of two levels: the *semi-automated* and the *fully automated level*, which are presented in Figure 15 (Omar, 2015).

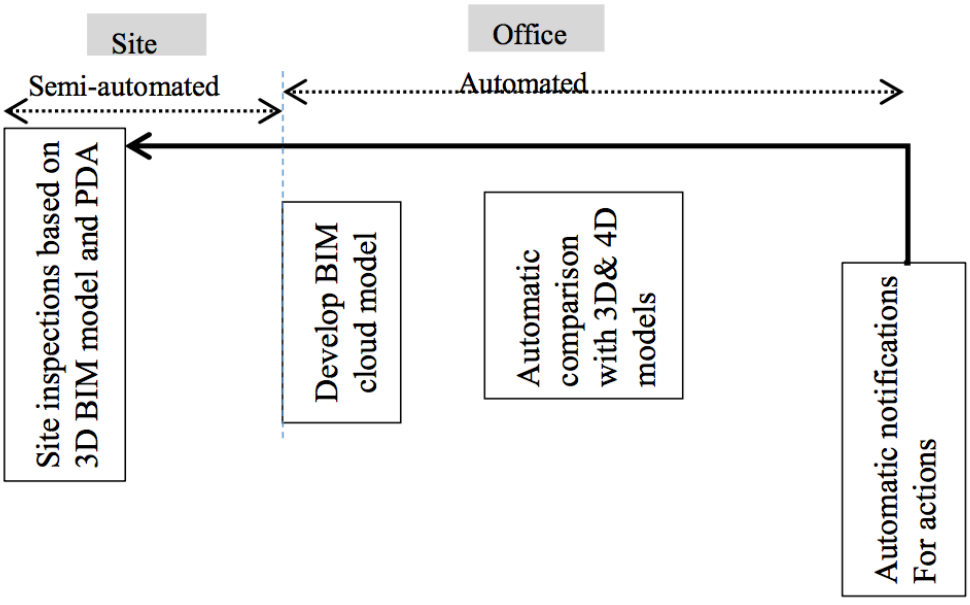

Figure 15: Proposed prototype (Omar, 2015, p. 52)

The first level, the *semi-automated process*, collects data from the site using the site inspectors who control and eliminate mistakes by using tablets or smartphones that are equipped with the BIM models. Based on the BIM model, an inspector is obliged to check the actual activities on the site. An inspector should fill in the check list on-site to avoid any errors. They can also review previous tests, etc. After reviewing the activities, the collected data is sent via Internet that is connected to the PDA devices to develop the BIM cloud model that continuously receives updates from the site. The second level, the *fully automated process*, automatically runs a comparison between the developed BIM cloud model and a 3D and 4D BIM to recognize any mistakes. The system will also consider delays and advise on the required manpower and equipment to recover the delays. The system is currently in the development phase and should be tested soon (Omar, 2015).

3 INTERNATIONAL AND NATIONAL NORMATIVE DOCUMENTS

this chapter, international norms and standards regarding BIM are presented as well as norms in DACH+SI region. In the scope of the master thesis, we also performed interviews with experts in the BIM field, which enabled us to get a better insight on the current development of the BIM in Austria.

3.1 Building SMART

BuildingSmart was established in 1996 in London, with a vision for quality, engagement and community for the Open BIM within the global built environment sector (BuildingSmart.org). Within BuildingSMART, the IFC standard was developed and is also aiming to focus on standardizing the processes, workflows and procedures for BIM. With the standardized BIM-processes, the owners, architects, engineers, facility managers, software vendors, educators, etc. would benefit greatly from the BIM processes because everyone would be acquainted with the standard procedures, a lot of money and effort would be saved, the educators would know what to teach the students at the Universities about the BIM, the work processes would be more efficient and streamlined and so on. Therefore, the fully available open international standards are needed and BuildingSMART is working towards this goal (BuildingSmart.org).

3.1.1 Building Smart Data Dictionary (bSDD)

The bSDD is a library of objects and their attributes (Data dictionary, building SMART) The purpose of the dictionary is to identify the objects in the built environment and their properties no matter which language a team operates in. Therefore, a window or some other building element means exactly the same thing all over the world. The Data Dictionary is open and international, which allows architects, engineers, owners, operators, etc. and also the suppliers and manufacturers of products to exchange the product information. It defines general terms of objects, but software developers can work with these general terms in order to create specific objects (Data dictionary, building SMART). The greatest feature of the bSDD is that it maps the relationships between objects and their property definitions; it also creates data transparency and is easy, open and international. The most important benefits of the bSDD include the following: reducing costs and improving the quality by sharing the reusable object

libraries, objects and property definitions are compatible with all software, it prevents miscommunication and data duplication with Automatic Rule Checking, property sets can be extended for specific requirements, etc. (Data dictionary, building SMART). To access the bSDD you don't even have to register on the website but is recommended. The bSDD is available on the following website: http://bsdd.buildingsmart.org/#.

3.1.2 Industry Foundation Classes (IFC)

The IFC (Industry Foundation Classes) is an object oriented data format and international standard that is used in the BIM to describe, exchange and share information across different software applications. The IFC was first developed in 1994 by the Industry Alliance for Interoperability and has been registered with the International Standardization Organization in 2013 as ISO16739 for data sharing in the construction and facility management industries (Industry Foundation Classes, 2017). The goal is to make the IFC the main international standard for the BIM data exchange. The aim is to solve the problem of a virtual building model exchange between different software. The current ISO 16739:2013 standard for data sharing in the construction and facility management industries specifies the conceptual data scheme and an exchange file format for BIM data that can be exchanged and shared between different software applications that are used by different teams and participants in a project (ISO 16739:2013). The standard was published in 2013 and will be reviewed every 5 years. Within the standard, the following is considered: the BIM exchange format definitions that are required during the life cycle phases of building, the BIM exchange format definitions that are required by the various disciplines that are involved in the life cycle phases and the BIM exchange format definitions that include project structure, physical components, spatial components, analysis items, processes, resources, controls, etc. (ISO 16739:2013). Outside of the domain the standard, however, does not consider the exchange format definitions of construction and facility maintenance and project structure and component breakdown structure outside of building engineering and behavioural aspects of components and other information items (ISO 16739:2013).

3.1.3 International Framework for Dictionaries (IFD)

To successfully exchange information between two or more computer systems, it is important to enable ability to automatically interpret the information that are needed to be exchanged accurately. Therefore, buildingSmart International Alliance for

Interoperability is persuading to improve this inteoperability through standards. One of those is International Framework for Dictionaries (IFD) where it is determined what are we sharing with our models. IFD Library is an open library that supports the implementation od buildingSmart technology in the construction industry through IFC and IDM [30]. IFD Library has a mapping mechanism, where all properties of an element from briefing documents and CAD systems are in one place and is important because it defines all properties of a certain element [30].

3.1.4 Information Delivery Manual (IDM)

When working BIM there still a lot of misscommunication between all participants in the organisation when it comes to exchange of information. Mostly, because they do not know which and when different kind of information has to be communicated [32]. Therefore, buildingSmart developed a standard to deliever a methodology to capture and specify processes and information flow through the lifecycle of a building, ISO 29481 – 1:2010, called »Building information modelling – Information delivery manual – Part 1« [32]. The purpose of a standard is to deliever a guideline of information exchange for new and existing projects. It is expected to expand the standard with exchange scenarios and to define stages in a communication process between parties [32].

3.1.5 Model View Definition (MVD)

BuildingSmart developed official Model View Definitions, or IFC View Definitions, that are defining IFC schemes subsets. Those are needed to allow exchange of information between Software through IFC file to include all the information and to satisfy the exchange requirements of the AEC industry. Internationally other MVDs are being developed by different organizations and will be considered by buildingSmart to become accepted [31].

3.1.6 Open BIM Collaboration Format (BCF)

Open BIM Collaboration Format (BFC) was adopted by buildingSmart as a buildingSmart standard. BFC is an open file that supports workflow communication in BIM processes in XLS format [33]. It is used to add comments, screenshots, 3D views, etc. to IFC models generated by different Software. [34] it is a communication tool that

enables to solve issued and improve working with BIM and IFC. it is very helpful to project organisation and can be used in projects of all stages, sizes and teams. The BCF can be used anytime as soon as you start using IFC [34].

3.2 Normative documents in Austria, Germany, Switzerland and Slovenia

3.2.1 Austria

3.2.1.1 ÖNORM 6241

The Önorm 6241 is an Austrian BIM standard that was published in 2015 in two parts: Önorm 6241-1 and Önorm 6241-2 and is obligatory to take into account while delivering the BIM projects in Austria. The Önorm 6241-1 contains a document- based exchange of information in the BIM Level 2. In the Önorm 6241-1 contains the methods of creating, maintaining and networking the integral virtual CAD model from the beginning of the building process (starting with the first building layout) to the end of the building life cycle (demolition of the building). The Önorm 6241-2 contains a model-based exchange of information in the BIM Level 3 (iBIM). The basic of the Önorm 6241-2 is a complete integral and collaborative process of modelling a virtual building model in accordance with the execution for the data maintenance over the entire life cycle in a common central data model with the incorporation of data for further information, which are described as additional dimensions (standard A6241).

The speciality of the Önorm 6241 is the control of the information density of all elements for each planning phase on the characteristic server that is freely accessible at: db. freebim.at. With the implementation of the software industry the phase-dependent filtering of the data to be exchanged is possible. In addition, the automated inspection of the planning data is easy to carry out (standard A6241).

In the following section some of the current work and projects in Austria regarding BIM development, implementation and improvement in current processes and software development are presented. To gather the needed information, interviews with expert responsible for the development of the Property server and Side server were made.

3.2.1.2 Property Server

The Property server was developed by the Austrian company Plandata. Within the project Free BIM 1, the Property server 1.0 was created, but it was too chaotic and not understandable for the users, therefore, they are developing the Property server 2.0 within the project Free BIM 2, where they are trying to develop a leaner and understandable interface. Until now, they have managed to implement 85 % of the properties that are needed for a planning procedure for a building, but the IMP parameters should still be implemented. The main purpose of the Property server is to put the number of the planning stage next to the property. The server contains the international data Industry Foundation Classes (IFC) and the Building Smart Dictionary (BSD) sets as well as different properties for the objects from the BSD standard, such as windows, walls, columns, etc. Every entry on the Property server has a link directly to the BSD and IFC. The big advantage of the Property server is having a precise knowledge about – down to the attributes of an element – the planning stage and which information have to be delivered and by whom, because none of the BIM standards are actually offering this right now. The Property server can also help us understand the processes in BIM, because we can determine exactly which attributes and parameters have to be set, by whom and in which stage, and this really clears out how BIM is working and can also accelerate the Open BIM workflows, because we can work with data bases instead of data formats and we can define them however we want it to, even in Excel, etc. (expert interview).

Along with the Property server, the ÖNORM 6241 was developed and released in 2015. The purpose of the ÖNORM 6241 was to make it an international standard, which all software developers, planners, etc. will be obligated to use to deliver the projects. At the moment, there are different standards around the world and different investors want to have projects delivered by different standards, which is very hard for the planners. Therefore, the Property server is coordinated with the ÖNORM 6241 and the IFC. Within the development of the Property server, they are also trying to implement all other standards, to make planners' work easier and faster (expert interview).

3.2.1.3 SIDE server

The Austrian company SIDE also has its own company server called the Side server. They are hosting a Revit server by Autodesk in a Vienna computer centre where different companies are working together. It is a central database for architects and bearing planners and is an infrastructure for connecting both parties. It was created to

make the team work on a common BIM project possible and more efficient (expert interview).

3.2.1.4 Merkmalsserver (Property server)

Within the project Free BIM Tirol 2, which took place in 2016, with an intention to make BIM useful in practice, Free BIM Tirol project participants also started with the development of the Merkmalsserver, which is still under construction. It is supposed to be an internationally unique server, designed and taken into account in the form of a working group of the new BIM-CEN standard, the CEN TC 442. The server serves to ensure a common language for the description of the components so that they can be described clearly and without mistakes. In the Merkmalsserver, the properties of the components and materials are collected in collaboration with the research project Free BIM Tirol and the goal is to match those properties with the Building Smart Data Dictionary (bSDD) and supplement them with the non-existing values. This would give each parameter a globally unique identifier (GUID), which defines the properties uniquely and independently. Those properties can be further combined with the information such as the Free Class, COBIE, etc. The parameters are mapped to the properties in the respective BIM software, which creates a link between the model and the GUIDs. Within the Merkmalsserver, the properties are also assigned to their phases to enable a clear perspective on which information is required in which phase (FreeBIM).

3.2.2 Germany

3.2.2.1 VDI 2552

The VDI 2552 is a German guideline for BIM that consists of 9 main parts: Framework Directive, Terms and Definitions, Quantities and Controlling, Model Contents and Data Exchange, Data Management, Facility Management, BIM Processes, BIM Qualifications, BIM Classification and BIM Quantities (VDI).

The VDI 2552 Part 3 »Building Information Modelling – quantities and controlling« is a German guideline for BIM and recognizes the rules of technology for BIM. The guideline describes the application of BIM for controlling structures regarding cost calculations, scheduling, tendering, execution and billing for all the participants involved in the construction who want to design processes with the help of shared data as well as for the suppliers. The VDI 2552 also serves as a national standpoint in the

international standardization bodies. The main focus is the identification of policy topics and the preparation of opinions and recommendations to the policy makers (VDI).

The goal of the German Federal Ministry of Transport and Digital Infrastructure is to encourage the BIM pilot projects in order to achieve the optimal approaches to the BIM transition in Germany and make BIM mandatory on all transport projects by 2020 (expert interview)

3.2.2.2 Computer-aided Facility Management (CAFM) and PIT

The company pit-cup GmbH from Heidelberg, Germany produces pit-FM, which is the main product, pit-cup software for building technology (CAD), pit-FM (CAFM) for facility management software that is also possible as an Internet solution, called pit-WEB or as an App for Smartphones and tablets with iOS or Android operating system. The CAFM is a Computer-aided Facility Management and is a support for the facility management processes with Software. Since most companies already have software for production, human resources, etc., it is a huge task to implement the CAFM-system in the existing landscape. In Ing. Günter Grüner GmbH, they aim to be one of the leading players for the BIM tools with their products for architecture, building technology and facility management (expert interview).

The advantages of pit-FM are at the same time its disadvantages. Pit-FM is very flexible and can adapt to different needs of customers and industry. Therefore, the application is done on a large scale and is complex since it is offering more than 100 modules, the so-called functional areas, from which we can choose. The disadvantage of it is therefore that customers mainly do not want to use the standard application, but a solution that is adapted to them. As a result, the implementation takes longer than for a standard software. The software can be used by everyone. From the present day, the diversity of customers is great, from hospitals, automotive suppliers, banks, cities and municipalities, universities, the Republic of Austria to the Federal Real Estate, etc. The big advantage of pit-FM is also that it can be used worldwide because it is programmed as language-neutral. What is more, the roots of the pit software and the philosophy of the concept is a computer program to support a continuous process and flow of data for planning and building and the same thing is today called BIM. Since pit is a German product, its main focus is on the DIN standards, the VDI and VDMA standards. But a large part of the DIN standards is already translated into ISO standards and vice versa since Germany is a great player in Europe. The great advantage of pit is also that it is

an open system, therefore, the catalogues and records from the country-specific regulations can be imported (expert interview).

3.2.3 Switzerland

3.2.3.1.1 SwissBIMLibrary

With the collaboration of the ETH Zürich and the Swiss Civil Engineering, the SwissBIMLibrary was created, which is accessible on the website for planners, companies, builders, etc. and consists of systems and products needed to begin the planning process of the building. In this library, the real products are digitalized and transferred as the BIM Objects. The Objects can be updated by the manufacturers when the properties change, so the library is always up to date for all users. It is a platform that offers the objects needed for the building process, which are described with all the parameters and attributes that are mandatory in the whole life cycle of a building (SwissBIMLibrary).

3.2.4 Slovenia

In Slovenia, the BIM experts are currently preparing the Manual for preparation of terms of reference for implementation of BIM approach in the Built Environment and Action plan for implementation of digitalization in the Built Environment.

3.2.4.1 Manual for preparation of terms of reference for implementation of BIM approach in the Built Environment

The purpose of the document is to define goals of using BIM with the organisation of the BIM process as well as roles and responsibilities of all parties involved in the process, such as BIM manager, BIM coordinator, etc. In the mannuals it is also planed to define information requirements of BIM model, technical requirements of BIM model, quality control, etc. Document will be intended for the use of investors that will want to implement BIM. The manual will summarize the contents from various national guidelines, which are adapted based on the experiences from the first BIM pilot projects that were recently carried out in Slovenia.

3.2.4.2 Action plan for implementation of digitalization in the Built Environment

An action plan for the introduction of digitization in the area of the built environment and the basis for applying the standards in the BIM system for investments is planed to cover:

- Production of professional bases: Time-bound activities that lead to a gradual increase in digitization to built environment, cost estimation of the action plan implementation plan, assessment of the impacts of the implementation of the Action Plan on the economy (potentials, weaknesses, risks), proposals to measure the effects of digitization in the area of the built environment that can be achieved through the implementation of the Action Plan and impact of the implementation of the Action Plan on related industries and wider context of social development.
- Creation of an action plan with the following content sets: Assessment of the current state of digitization (or the use of information technologies) on the area of the built environment in the Republic of Slovenia, identification of the needs for the digitization of the built environment in the Republic of Slovenia (understanding the lifecycle of buildings in the built environment, the production of BIM guidelines for private and public contractors of projects, production of building classification systems elements, building systems, etc.) and identification of stakeholders that should be included in the digitization process in the area of built environment in the Republic of Slovenia by fields (construction, architecture, mechanical engineering, electrical engineering, ICT) and by applications.

4 METHODOLOGY

This thesis was a part of the study Digitalisierungsbarometer 2017, Switzerland and was developed with in collaboration with the HSLU Switzerland, the TU Munich and the TU Wien. The main aims of the thesis were:

- Statistical analysis of the Slovenian questionnaire results using Spearman's rank correlation.
- Developing hypotheses to determine the implementation of BIM, its usage and challenges.
- Statistical analysis of the DACH region questionnaire results using Spearman's rank correlation.
- A comparison study between Slovenia and the DACH region and the evaluation of hypotheses.
- Expert interview for the evaluation of questionnaire results.

4.1 SPEARMAN'S RANK CORRELATION

4.1.1 General information about Spearman's rank correlation

Correlation is a bivariate analysis that measures the strengths of association between two variables and the direction of the relationship (Statistic solutions). In statistics, four different types of correlation are usually measured: *Pearson correlation*, *Kendall rank correlation*, *Spearman's correlation* and *Point-biserial correlation* (Statistic solutions). Since Spearman's rank correlation was used in this research, only this one is presented in detail.

Spearman's rank correlation is normally used to test the connection between two ranked variables or one ranked and one measurement variable (McDonald, 2014) Therefore, we can find out whether two ranked variables covariate, what is the strength of the connection between them and what happens if one variable increases. We can also use Spearman's correlation instead of linear regression if we are not sure about the non-normality (McDonald, 2014). When measuring the strength of the relationship between two variables, the value of the correlation coefficient should be between +1 and − 1, which means that when the value of the *Spearman's correlation coefficient* (ρ) is close to ±1, the connection between two variables is significant, and when the correlation coefficient is close to 0, the connection is weak or not relevant. When

the value of the correlation coefficient is 0, the connection between two variables does not exist, also called the *Null hypothesis.* The Null hypothesis means that if the ranks of one variable increase, the ranks of other variable do not increase or they decrease (McDonald, 2014) The direction of the relationship is presented with + or – sign (+ indicates a positive relationship between variables and – indicates a negative relationship between variables) (Statistic solutions).

4.1.2 Spearman's correlation coefficient

Spearman's rank correlation does not assume the distribution of the data, it only assumes that the observations are independent (McDonald, 2014), also the data should be normally distributed.

Spearman's rank correlation is calculated using the following equation:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$ (Equation 1) (Statistic solutions).

Where:

ρ: Spearman's rank correlation

d_i: the difference between the ranks of the corresponding values x_i and y_i

n: the number of values in each data set

As already written, the value of ρ is between – 1 to + 1. To determine the strength of the relationship, the *Cohen's standard*[1] is used, where values of ρ between 0.10 and 0.29 represent a small association, values of ρ between 0.30 and 0.49 represent medium association and values of ρ above 0.50 represent large association (Statistic solutions).

[1] Effect size: quantitive measure for strenght of a correlation between two variables.

5 STATISTICAL ANALYSIS USING A QUESTIONNAIRE

5.1 Questionnaire sample and methods

Within the study the Digitalisierungsbarometer 2017, a questionnaire for the DACH region was created to evaluate the usage and implementation of BIM. In collaboration with the HSLU, Switzerland, a questionnaire was translated to the Slovenian language to extend the research and make a comparative study between Slovenia, Austria, Germany and Switzerland. The main purpose of the research was to reach the BIM experts and companies working with BIM as well as other companies who are not yet using BIM, to get an insight on the satisfaction, challenges, implementation, costs, etc. regarding BIM in those countries and make a comparison between the companies who are already using BIM and those who are not using it jet or are planning to implement BIM in the future. To do this, a questionnaire was sent to different companies and individuals. The sample of the participants in each country consisted of civil engineers, architects, developers, investors, users, supervisors and others with a purpose to consider the entire architecture construction engineering (AEC). The number of the returned questionnaires in Switzerland was 2249, in Austria 409, in Germany 340 and in Slovenia 119. For the results to be accurate, we eliminated the answers of all participants who needed less than 300 seconds to finish the questionnaire, because we predicted that the time needed to thoughtfully answer all question was at least 300 seconds. Therefore, the input numbers of participants for further analysis, as seen in Table 1, were as follows: Switzerland 1294, Austria 232, Germany 229 and Slovenia 63.

Table 1: Sample overview

	Number of returned questionnaires	Number of valid questionnaires
Slovenia	119	63
Germany	340	229
Austria	409	232
Switzerland	2249	1294

For the research, different correlations were examined with the Software for Statistical Data processing, called SPSS and MS Excel. To determine if the correlations between different variables exist, we used Spearman's rank correlation, because it is one of the most appropriate

methods to find out whether two variables covariate or not. The general information and formulas regarding Spearman's rho correlation are described in SPEARMAN'S RANK CORRELATION.

Before we started the evaluation of the questionnaire answers, we also determined the terms *big* and *small companies*, where big companies are considered as companies who have more than 49 employees and small companies the ones who have up to 48 employees. For a method of a research to be exact, we predicted several hypotheses that we wanted to test and that were valid for the whole DACH + SI region. The hypotheses were:

- Hypothesis 1: In the companies in which new methods were implemented, digitalization created new income.
- Hypothesis 2: The usage of BIM is higher among younger engineers.
- Hypothesis 3: Large companies operate with more BIM projects.
- Hypothesis 4: The companies who anchored the digitalization are also using BIM.
- Hypothesis 5: The more often that companies are using BIM, the lower are the costs.
- Hypothesis 6: More than half of Slovenian companies are currently in the BIM Level 2.
- Hypothesis 6: More than half of the companies in the DACH region are currently in the BIM Level 2.

After processing all the results that are discussed in the next chapter RESULTS AND DISCUSSION, we were able to confirm and disprove the hypotheses we predicted before the research and which are shown in Table 2.

Table 2: Confirmation of the hypotheses

Confirmation of the hypotheses			
Hypothesis		**Confirmed**	**Disproved**
1. Hypothesis	In the companies, in which new methods were implemented, digitalization created new income.		
2. Hypothesis	The usage of BIM is higher among younger engineers.		
3. Hypothesis	Large companies operate with more BIM projects.		
4. Hypothesis	The companies who anchored the digitalization are also using BIM.		
5. Hypothesis	The more often that companies are using BIM, the lower are the costs.		
6. Hypothesis	More than half of Slovenian companies are currently in the BIM Level 2.		
7. Hypothesis	More than half of the companies in the DACH region are currently in the BIM Level 2.		

Even though only two hypotheses were confirmed and four were disproved, we can say that the research and hypotheses were successful, because we were able to answer all the questions we posed at the beginning of the research.

6 RESULTS AND DISCUSSION

Within the research, we decided to divide the results into two parts. *Part 1*: results for Slovenia and *Part 2*: a comparative study for Slovenia, Austria, Germany and Switzerland. The working methods were the same for both parts. We checked the same hypotheses for Part 1 and Part 2. In addition, the same variables were taken into account to determine the correlations.

6.1 BIM in Slovenia

In Slovenia, BIM is a rather interesting novelty and is more and more discussed in engineering circles. In the next subchapters the results regarding the usage and implementation of BIM in Slovenia are presented.

6.1.1 Correlation between new incomes and goals reached due to digitalization for Slovenia

To determine whether the correlation between new incomes and goals reached due to digitalization exists, we searched for a potential correlation between two variables: *Variable 1* (Where in the last two years new planning methods implemented in your company?) and *Variable 2* (Digitalization created new income). The results for this correlation are presented in Table 3, where we can see that there is a weak connection between those two variables in a value of correlation coefficient of 0.302.

Table 3: Correlations between implementation of new methods and new income

Correlations				
			Were in the last two years new planning methods implemented in your company?	Digitalization created new income
Spearman's rho	Were in the last two Years new planning methods implemented in your company	Correlation Coeff.	1.000	0.302
		Sig. (2-tailed)	0.000	0.078
		N	43	35
	Digitalization created new income	Correlation Coeff.	0.302	1.000
		Sig. (2-tailed)	0.078	0.000
		N	35	48

Furthermore, we created a Cross Table 1 to see the correlation between new incomes regarding digitalization and other variables that digitalization influenced.

Cross Table 1: Percentage of valid improvements regarding the implementation of digitalization

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Digitalization created new income * Saving costs	6	24.0%	19	76.0%	25	100.0%
Digitalization created new income * Increased speed	13	52.0%	12	48.0%	25	100.0%
Digitalization created new income * Simplified internal processes	13	52.0%	12	48.0%	25	100.0%
Digitalization created new income * Improved networking with suppliers/ Customers/project participants	9	36.0%	16	64.0%	25	100.0%
Digitalization created new income * New product /services	15	60.0%	10	40.0%	25	100.0%
Digitalization created new income * Suggested from the customers	1	4.0%	24	96.0%	25	100.0%
Digitalization created new income * Detachment of the old system	6	24.0%	19	76.0%	25	100.0%
Digitalization created new income * Other	2	8.0%	23	92.0%	25	100.0%

Lastly, we created a cross tabulation to get the exact number of improvements regarding the implementation of digitalization. The results are shown in the Cross Table 2, where we can see whether the costs were saved due to digitalization depending on other variables as presented in the Cross Table 1.

Cross Table 2: Costs changes due to digitalization

Digitalization created new income * Saving costs cross tabulation

Count		Saving costs			Total	
		Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	1	4	1	6	55.5555
	No	1	0	0	1	5.5555
	Stayed the same	1	1	0	2	11.1111

Digitalization created new income * Improved speed cross tabulation

Count		Improved speed				Total	
		Completely disagree	Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	1	1	7	4	13	52.3809
	No	0	0	3	1	4	19.0476
	Stayed the same	0	0	4	0	4	19.0476

Digitalization created new income * Simplified internal processes cross tabulation

Count		Improved internal processes				Total	
		Completely disagree	Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	1	1	7	4	13	55
	No	0	0	2	2	4	20
	Stayed the same	0	0	2	1	3	15

Digitalization created new income * Improved networking with suppliers/customers/ project participants cross tabulation

Count		Improved networking with suppliers / customers / project participants				Total	
		Completely disagree	Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	0	0	5	4	9	64.2857
	No	0	0	2	0	2	14.2857
	Stayed the same	0	0	3	0	3	21.4285

Digitalization created new income * New products/services cross tabulation

Count		New products / services				Total	
		Completely disagree	Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	0	1	7	7	15	41.1764
	No	0	0	4	0	4	11.7647
	Stayed the same	0	1	7	7	15	41.1764

Digitalization created new income * requested from customers cross tabulation

Count		Requested from the customers			Total	
		Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	0	1	0	1	100
	No	0	0	0	0	0

Digitalization created new income * Detachment of an old system cross tabulation

Count		Detachment of an old system			Total	
		Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	1	2	3	6	45.4545
	No	0	3	1	4	36.3636
	Stayed the same	0	1	0	1	9.0909

Digitalization created new income * Other cross tabulation

Count		Other			Total	
		Disagree	Agree	Completely agree	Count	%
Digitalization created new income	Yes	0	2	0	2	50
	No	0	2	0	2	50

From the results, it is clearly seen that costs due to digitalization in combination with other factors in most cases created new income. For example, in Cross Table 2 we can see that 55.555 % of participants agreed or totally agreed with the statement that digitalization created new

income and also the costs were saved. Furthermore, with digitalization, the speed improved for 52. 381% and also the networking with suppliers, customers and project participants improved for 64.276 %.

6.1.2 The Usage of BIM among civil engineers in Slovenia

Within the research, we wanted to determine whether the use of BIM is higher among younger civil engineers. To do so, we took into account only the participants who were civil engineers. Firstly, we checked whether there is a correlation between the usage of BIM and the age of the users. In Table 4, we can see that the correlation factor is in the value of – 0,667, meaning that correlation is significant at the 0.01 level.

Table 4: Correlation between the usage of BIM and the age of the users

Correlations				
			How well do you know the BIM planning method?	How old are you?
Spearman's rho	How well do you know the BIM planning method?	Correlation Coefficient	1.000	-0.667**
		Sig. (2-tailed)	0.000	0.001
		N	22	45
	How old are you?	Correlation Coefficient	-0.667**	1.000
		Sig. (2-tailed)	0.001	0.000
		N	22	22

** Correlation is significant at the 0.01 level (2-tailed).

Furthermore, we wanted to see how well BIM is known between different age groups of civil engineers. Results shown in Figure 15 showed that BIM is best known among civil engineers in the age group between 36 and 45 years (31.81 % of participants answered that they know BIM well and are using it for more than one year) and also between engineers who are of the ages between 26 and 35 (22.72 % of participants answered that they know BIM well and are using it for more than one year). The reason why BIM is not so well known or used among older civil engineers could be the lack of desire for learning new methods or the working position in the company. Only 4.54 % of the participants from this age group answered that they know BIM and are using it longer than one year, and also 27.27 % of the participants who were older than 45 years answered that they know BIM, but are using it for less than one year. This could mean that those participants are in the positions of project supervisors or directors of the companies and have to know the basics regarding BIM and the BIM Software.

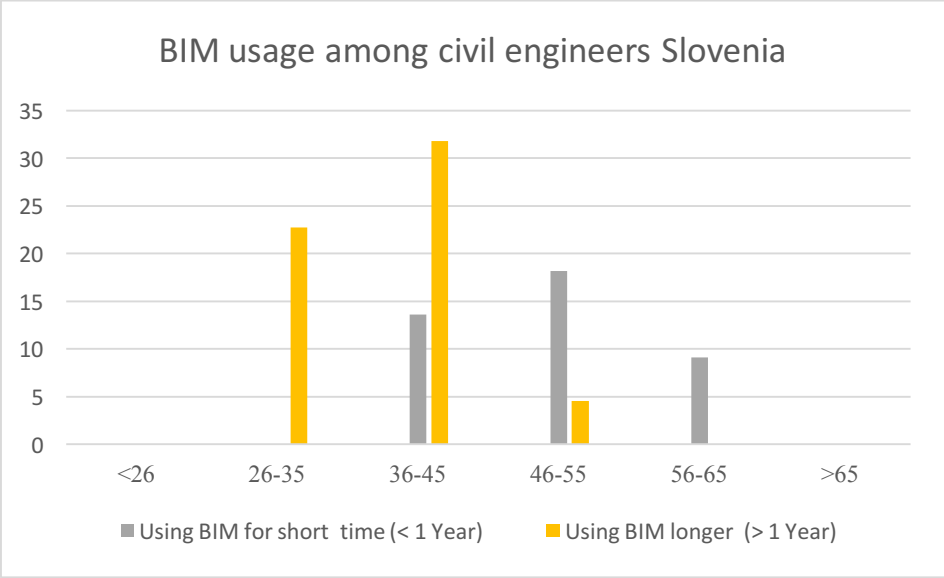

Figure 15: Usage of BIM among civil engineers

6.1.3 BIM projects operating in Slovenian companies

The research about the operation with BIM projects in companies was also made because we wanted to determine whether the planning with BIM is higher in large companies. The correlation factor between the percentage of the projects planned mainly with BIM and the size of the projects, shown in Table 5, was – 0.236 and represents a slight correlation between those two variables.

Table 5: Correlation between the size of projects and the use of BIM in companies

Correlations				
			What percentage of your projects are you mainly planning with BIM?	What is the average size of the projects in your company?
Spearman's rho	What percentage of your projects are you mainly planning with BIM?	Correlation Coeff.	1.000	-0.236
		Sig. (2-tailed)	0.000	0.180
		N	35	34
	What is the average size of the projects in your company?	Correlation Coeff.	-0.236	1.000
		Sig. (2-tailed)	0.180	0.000
		N	34	42

To get a better understanding of the correlation, we examined the results more carefully and found out that the reason for the weak correlation is that there are not many large companies in Slovenia. In Figure 16 it is shown that the usage of the BIM models in the companies who mostly work on the projects in excess of 10,000.000 EUR is between 20 and 100 %, on average

60 %, and in companies who mostly work on the projects in value of around 25,000,000 EUR, the use of BIM as the main model is around 20 %. To conclude, the usage of the BIM models as main models in projects is the highest in the companies whose projects are worth about 10,000,000 EUR.

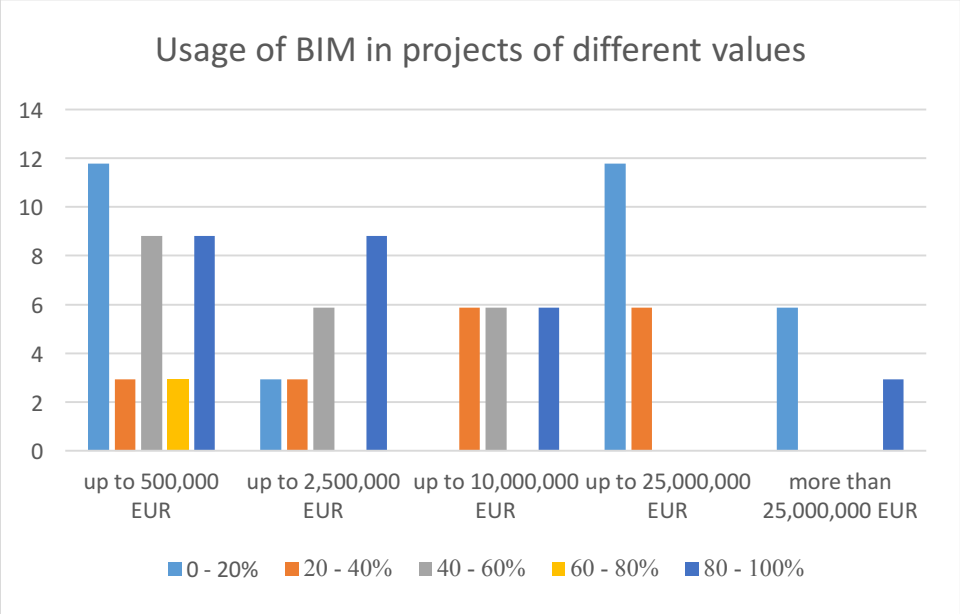

Figure 16: Usage of BIM in projects of different values

6.1.4 Usage of BIM depending on the digitalization anchoring in Slovenia

To determine whether there is a connection between how the digitalization is anchored in a company and how well the BIM planning method is known in a company, we created the cross tabulation and divided all the answers of the participants into two groups: *Group 1* and *Group 2*, where Group 1 represents the answers of the participants who do not really know BIM and are not using it and Group 2 the participants who are using BIM and are well aware of it. From the answers in Cross Table 3, we can see that BIM is well known in the companies who anchored digitalization, represented in the 70.45 % of the answers. This tells us that the use of BIM is related to the implementation of digitalization in companies, therefore the more digitalization is anchored in the company, the more likely it is that these companies are also very familiar with BIM and also use BIM in planning.

Cross Table 3: Cross tabulation of the digitalization anchoring and being acquainted with BIM

Is the topic Digitalization anchored in your company * How well do you know the BIM planning method cross Tabulation						
		Group 1		Group 2		
		Count	%	Count	%	
Is the topic Digitalization anchored in your company?	No	1	2.27	3	6.81	4
	Yes	9	20.45	31	70.45	40
Total		10		34		44

6.1.5 Frequency of BIM usage in addition to costs in Slovenia

To determine whether the frequency of using BIM in companies influences the costs altogether we made a cross tabulation. The results are separated into two groups: *Group 1* and *Group 2*, where Group 1 represents the answers of the participants who do not really know BIM and are not using it and Group 2 the participants who are using BIM and are well aware of it. In Cross Table 4, the results are presented, and we can see, that there is no significant positive influence of the BIM usage frequency on the costs altogether in a company, because 36.111 % of the participants in Group 2 answered that the costs have risen with implementing BIM into their processes and 30.555 % said that the costs stayed the same. The reason for this could be that most of the companies in Slovenia are using BIM for about 1 year, when the costs for implementing BIM, the education of employees, buying specific Software, etc. are the highest.

Cross Table 4: Frequency of BIM usage and costs in general

Costs altogether* How well do you know the BIM planning method cross tabulation						
Count		How well do you know the BIM planning method				Total
		Group 1		Group 2		
Costs altogether have	Risen	2	5.555	13	36.111	15
	Stayed the same	3	8.333	11	30.555	14
	Lowered	1	2.777	6	16.666	7
Total		6		30		36

6.1.6 BIM Level of Slovenian companies

Lastly, we wanted to determine what is the actual current BIM Level of Slovene companies., We therefore examined the answers of the participants and divided them into the sub-tables, where we can see the percentage of the usage frequency of a certain planning method. The results are shown in Table 6, where *valid percent* represents the percentage of the answers subtracted from the missing answers. In Table 6, the planning methods are taken into account as follows: *planning using 2D drawings, planning using 3D drawings*, *planning based on BIM models*, *4D BIM, 5D BIM* and *6D BIM.* Furthermore, Figure 17 shows a clearer picture over the current usage of certain planning methods. For a more transparent view, we took into account only the next frequencies of using certain planning methods: *planned in the future* and *using planning method always or often*.

Table 6: Frequency of using planning methods

Planning using 2D drawings					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	13	18.6	30.2	30.2
	Often	15	21.4	34.9	65.1
	Rarely	9	12.9	20.9	86.0
	Never	5	7.1	11.6	97.7
	Planned in the future	1	1.4	2.3	100.0
	Total	43	61.4	100	
Missing	Missing	25	35.7		
		2	2,9		
	Total missing	27	38,6		
Total	Total	70	100		

Planning using a 3D model					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	9	12.9	21.4	21.4
	Often	20	28.6	47.6	69.0
	Rarely	10	14,3	23.8	92.9
	Never	2	2.9	4.8	97.6
	Planned in the future	1	1.4	2,4	100.0
	Total	42	60	100	
Missing	Missing	25	35.7		
		3	4.3		
	Total missing	28	40		
Total	Total	70	100		

Planning based on building-oriented building models (BIM models)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	10	14.3	23.8	23.8
	Often	14	20	33.3	57.1
	Rarely	8	11.4	19	76.1
	Never	1	1.4	2,4	78.6
	Planned in the future	9	12.9	21.4	100.0
	Total	42	60	100	
Missing	Missing	25	35.7		
		3	4,3		
	Total missing	28	40		
Total	Total	70	100		

4D-BIM: Integration of process information					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	4	5.7	9.8	9.8
	Often	7	10	17.1	26.8
	Rarely	11	15.7	26.8	53.7
	Never	6	8.6	14.6	68.3
	Planned in the future	13	18.6	31.7	100.0
	Total	41	58.6	100	
Missing	Missing	25	35.7		
		4	5.7		
	Total missing	29	41.4		
Total	Total	70	100		

5D-BIM: Integration of process information					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	4	5.7	10	10.0
	Often	5	7.1	12.5	22.5
	Rarely	12	17.1	30	52.5
	Never	6	8.6	15	67.5
	Planned in the future	13	18.6	32.5	100.0
	Total	40	57.1	100	
Missing	Missing	25	35.7		
		5	7.1		
	Total missing	30	42.9		
Total	Total	70	100		

6D-BIM: Integration of process information					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	2	2.9	5.3	5.3
	Often	2	2.9	5.3	10.5
	Rarely	5	7.1	13.2	23.7
	Never	10	14.3	26.3	50.0
	Planned in the future	19	27.1	50	100.0
	Total	38	54.3	100	
Missing	Missing	25	35.7		
		7	10		
	Total missing	32	45.7		
Total	Total	70	100		

Figure 17 shows that most of the Slovenian companies are already using the BIM models for their planning, which is 57.1 % of all the participants, and around 200 % of the Slovene companies are already using the 4D, 5D and 6D models as their main models in projects. To conclude, we can say that most of the Slovene companies have already achieved the BIM Level 2.

Figure 17: Planning methods

6.2 A comparative study for Slovenia, Austria, Germany and Switzerland

To understand the Slovenian results better, within the master thesis, several correlations regarding the usage of BIM were also examined for Austria, Germany and Switzerland (the DACH region). The methods, correlations and variables examined were the same as for the Slovenian research, also the same software was used. The purpose of this research was also to compare the results between Slovenia, Austria, Germany and Switzerland, define what is the actual usage in those countries, what are the differences, what are the potentials, etc.

6.2.1 Correlation between new incomes and goals reached due to digitalization for the DACH + SI (Germany, Austria, Switzerland and Slovenia) region

To determine if any correlation between the new incomes and the implementation of digitalization in the company exists, we first ran Spearman's rank correlation for those variables for each country separately. In Table 7, the results present the values of the correlation factors between the two variables.

Table 7: Correlations between the implementation of new methods and new income

Correlations				
			Were in the last two years new planning methods implemented in your company	Digitalization created new income
SLOVENIA				
Spearman's rho	Were in the last two years new planning methods implemented in your company?	Correlation Coeff.	1.000	0.302
		Sig. (2-tailed)	0.000	0.078
		N	43	35
	Digitalization created new income	Correlation Coeff.	0.302	1.000
		Sig. (2-tailed)	0.078	0.000
		N	35	48

Correlations				
			Were in the last two years new planning methods implemented in your company	Digitalization created new income
SWITZERLAND				
Spearman's rho	Were in the last two Years new planning methods implemented in your company	Correlation Coeff.	1.000	0.176**
		Sig. (2-tailed)	0.000	0.000
		N	884	868
	Digitalization created new income	Correlation Coeff.	0.176	1.000
		Sig. (2-tailed)	0.000	0.000
		N	868	1256

** Correlation is significant at the 0.01 level (2-tailed)

Correlations				
	GERMANY		Were in the last two years new planning methods implemented in your company?	Digitalization created new income
Spearman's rho	Were in the last two years new planning methods implemented in your company?	Correlation Coeff.	1.000	0.159
		Sig. (2-tailed)	0.000	0.110
		N	115	102
	Digitalization created new income	Correlation Coeff.	0.159	1.000
		Sig. (2-tailed)	0.110	0.000
		N	102	163

Correlations				
	AUSTRIA		Were in the last two years new planning methods implemented in your company?	Digitalization created new income
Spearman's rho	Were in the last two Years new planning methods implemented in your company?	Correlation Coeff.	1.000	0.121
		Sig. (2-tailed)	0.000	0.203
		N	128	112
	Digitalization created new income	Correlation Coeff.	0.121	1.000
		Sig. (2-tailed)	0.203	0.000
		N	112	163

From Table 7 it is clearly seen that the correlation between the implementation of digitalization and its impact on the costs is not strong because the correlation factors for each country are as follows: Germany $\rho = 0.159$, Austria $\rho = 0.121$ *Switzerland* $\rho = 0.176$ and *Slovenia* $\rho = 0.302$. The results show that the strongest correlation between the variables was calculated for Slovenia, where $\rho = 0.302$. Therefore, we can say that in Slovenia, there is a certain correlation between the implementation of digitalization in a company and its impact on lowering the costs, but the correlation is not really strong. From the results presented in Cross Table 5, it is seen that the biggest impact on the costs due to the implementation of digitalization is present because of the increased speed of processes (52,0 %), simplification of internal processes (52.0 %) and because of new products and services that companies can offer because of the implementation of digitalization (60.0 %).

On the other hand, the correlation between before the mentioned variables is weaker in other countries (the lowest $\rho = 0.121$ in Austria and the highest $\rho = 0.176$ in Switzerland), meaning that in the companies who implemented digitalization, the implementation does not have a big impact on the costs. From

Cross Table 5, it is seen that the simplification of internal processes has the biggest influence on the costs because of the digitalization implementation in the DACH region: in Austria 21.1%, Switzerland 17.5 % and in Germany 17.0%.

Cross Table 5: Percentage of valid improvements regarding the implementation of digitalization

	Cases					
	Valid		Missing		Total	
SLOVENIA	N	Percent	N	Percent	N	Percent
Digitalization created new income * Saving costs	6	24.0%	19	76.0%	25	100.0%
Digitalization created new income * Increased speed	13	52.0%	12	48.0%	25	100.0%
Digitalization created new income * Simplified internal processes	13	52.0%	12	48.0%	25	100.0%
Digitalization created new income * Improved networking with suppliers / Customers / project participants	9	36.0%	16	64.0%	25	100.0%
Digitalization created new income * New products / services	15	60.0%	10	40.0%	25	100.0%
Digitalization created new income * Suggested from the customers	1	4.0%	24	96.0%	25	100.0%
Digitalization created new income * Detachment of an old system	6	24.0%	19	76.0%	25	100.0%
Digitalization created new income * Other	2	8.0%	23	92.0%	25	100.0%

	Cases					
	Valid		Missing		Total	
SWITZERLAND	N	Percent	N	Percent	N	Percent
Digitalization created new income * Saving costs	147	11.3 %	1153	88.7 %	1300	100.0%
Digitalization created new income * Increased speed	191	14.7 %	1109	85.3 %	1300	100.0%
Digitalization created new income * Simplified internal processes	227	17.5 %	1073	82.5 %	1300	100.0%
Digitalization created new income * Improved networking with suppliers / Customers / project participants	169	13.0 %	1131	87.0 %	1300	100.0%
Digitalization created new income * New products / services	116	8.9 %	1184	91.1 %	1300	100.0%
Digitalization created new income * Suggested from the customers	62	4.8 %	1238	95.2 %	1300	100.0%
Digitalization created new income * Detachment of an old system	92	7.1 %	1208	92.2 %	1300	100.0%
Digitalization created new income * Other	21	1.6 %	1279	98.4 %	1300	100.0%

	Cases					
	Valid		Missing		Total	
GERMANY	N	Percent	N	Percent	N	Percent
Digitalization created new income * Saving costs	35	15.3 %	194	84.7 %	229	100.0%
Digitalization created new income * Increased speed	35	15.3 %	194	84.7 %	229	100.0%
Digitalization created new income * Simplified internal processes	39	17.0 %	190	83.0 %	229	100.0%
Digitalization created new income * Improved networking with suppliers / Customers / project participants	32	14.0 %	197	86.0 %	229	100.0%
Digitalization created new income * New products / services	28	12.2 %	201	87.8 %	229	100.0%
Digitalization created new income * Suggested from the customers	17	7.4 %	212	92.6 %	229	100.0%
Digitalization created new income * Detachment of an old system	15	6.6 %	214	93.4 %	229	100.0%
Digitalization created new income * Other	2	0.9 %	227	99.1 %	229	100.0%

AUSTRIA	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Digitalization created new income * Saving costs	34	14.7 %	198	85.3 %	232	100.0%
Digitalization created new income * Increased speed	46	19.8 %	186	80.2 %	232	100.0%
Digitalization created new income * Simplified internal processes	49	21.1 %	183	78.9 %	232	100.0%
Digitalization created new income * Improved networking with suppliers / Customers / project participants	44	14.2 %	199	85.8 %	232	100.0%
Digitalization created new income * New products / services	2	9.1 %	211	90.0 %	232	100.0%
Digitalization created new income * Suggested from the customers	15	6.5 %	27	93.5 %	232	100.0%
Digitalization created new income * Detachment of an old system	21	9.1 %	211	90.0 %	232	100.0%
Digitalization created new income * Other	3	1.3 %	229	98.7 %	232	100.0%

6.2.2 Usage of BIM among civil engineers in the DACH + SI region

Furthermore, we checked the correlations between the age of the participants and their BIM awareness in the whole DACH region to compare it with the results for Slovenia. To do so, we took into account only the civil engineers who participated in the questionnaire. From the results, presented in Table 8, we concluded that there is a significant correlation between the age of the civil engineers and how well they know the BIM planning method in Slovenia, Switzerland and Austria, where $\rho = -0.667$ for Slovenia, $\rho = -0.346$ for Switzerland and $\rho = -0.338$ for Austria. On the other hand, the correlation of the variables for Germany is weak and is only $\rho = -0.190$.

Table 8: Correlation between the usage of BIM and the age of the users

Correlations				
SLOVENIA			How well do you know the BIM planning method?	How old are you?
Spearman's rho	How well do you know the BIM planning method?	Correlation Coefficient	1.000	-0.667**
		Sig. (2-tailed)	0.000	0.001
		N	22	45
	How old are you?	Correlation Coefficient	-0.667**	1.000
		Sig. (2-tailed)	0.001	0.000
		N	22	22

** Correlation is significant at the 0.01 level (2-tailed).

Correlations				
SWITZERLAND			How well do you know the BIM planning method?	How old are you?
Spearman's rho	How well do you know the BIM planning method?	Correlation Coefficient	1.000	-0.346**
		Sig. (2-tailed)	0.000	0.007
		N	59	59
	How old are you?	Correlation Coefficient	-0.346**	1.000
		Sig. (2-tailed)	0.007	0.000
		N	59	79

** Correlation is significant at the 0.01 level (2-tailed).

Correlations				
GERMANY			How well do you know the BIM planning method?	How old are you?
Spearman's rho	How well do you know the BIM planning method?	Correlation Coefficient	1.000	-0.190
		Sig. (2-tailed)	0.000	0.625
		N	9	9
	How old are you?	Correlation Coefficient	-0.190	1.000
		Sig. (2-tailed)	0.625	0.000
		N	9	13

Correlations				
AUSTRIA			How well do you know the BIM planning method?	How old are you?
Spearman's rho	How well do you know the BIM planning method?	Correlation Coefficient	1.000	-0.338
		Sig. (2-tailed)	0.000	0.170
		N	18	18
	How old are you?	Correlation Coefficient	-0.338	1.000
		Sig. (2-tailed)	0.170	0.000
		N	18	25

What is more, we wanted to see how well BIM is known between different age groups of civil engineers. For a clearer presentation of the results, we created two groups of the participants: *Group 1* represents the answers of the respondents who do not know BIM and are not using it and *Group 2* represents the answers of the respondents who know BIM well and are also using it. The *Results*, shown in Figure 18, showed that in Slovenia, BIM is best known among the civil engineers in the age group between 36 and 45 years and also between the engineers who are between 26 and 35 years of age, while BIM is not very well known among older civil engineers. Only 4.54 % of the participants from this age group answered that they know BIM and are using it longer than one year, but also 27.27 % of the participants who were older than 45 years answered that they know BIM, but are using it for less than one year. Furthermore, in Switzerland, BIM is best known among the civil engineers in the age group between 46 and 55 years, since 16.92 % of the participants answered they know BIM well and are using it for at least one year. Also, the participants between 36 and 45 years of age are in 15.38 % aware of BIM. On the other hand, BIM is not very known among the Swiss civil engineers who are between 26 and 35 years of age, since only 3.07 % of the participants answered that they know BIM and are using it. The similar situation is present in Germany, where BIM is also best known among the civil engineers who are between 36 and 55 years of age. In both age groups, 22.22 % of the participants answered that they know BIM and are using it for one year or more. Sadly, we cannot determine what is the BIM acceptance and usage among younger (<36 years old) and older (>55 years old) German civil engineers, because we did not have any participants from these age groups representing Germany. Moreover, in Austria BIM is best known among

younger engineers who are between 26 and 35 years of age. The percentage of the engineers who are using BIM and know it well in this age group is 16.667 %. In addition, BIM is less known among Austrian engineers older than 35 years.

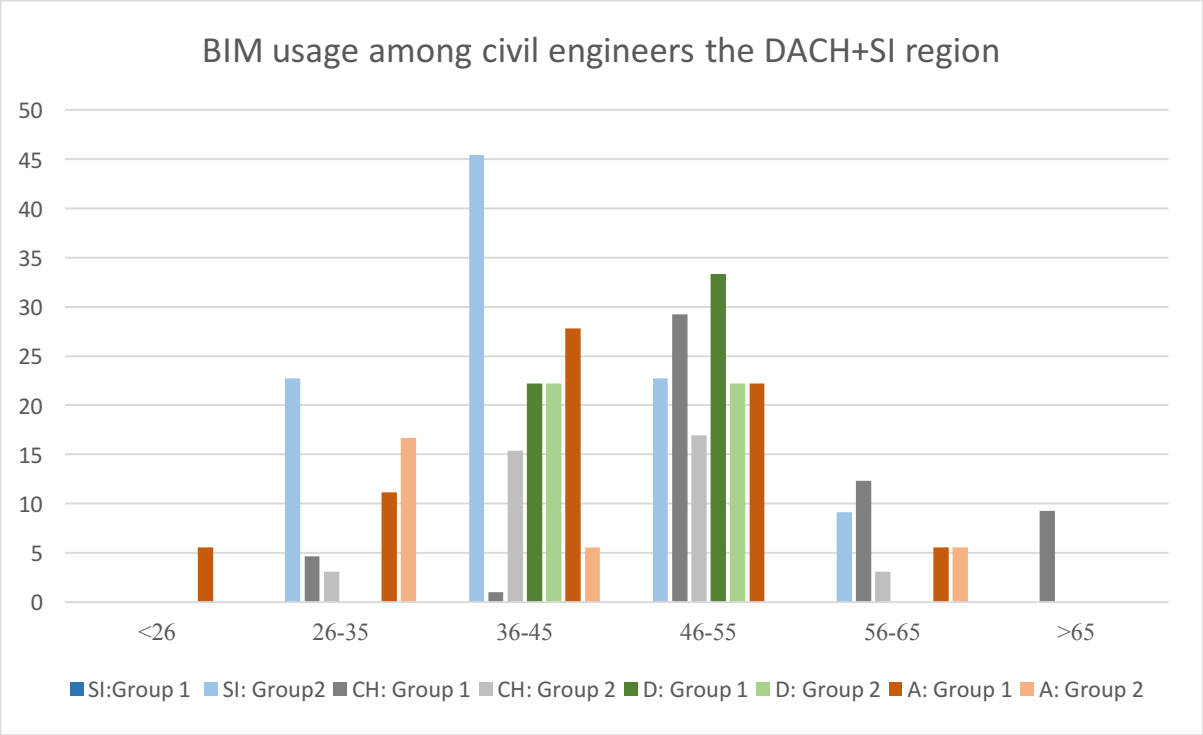

Figure 18: Usage of BIM among civil engineers for the DACH + SI region

To conclude, we can say that in the whole DACH + SI region, BIM is well known among the civil engineers who are between 36 and 55 years old. What is more, in Slovenia, Switzerland and Austria, BIM is known among a few percentages of older engineers. The reason for this could be that those participants are directors of companies, supervisors or similar and they have to be well acquainted with BIM because of the nature of their work.

6.2.3 Operating with BIM projects in companies in DACH + SI region

Furthermore, we wanted to see if there is a connection between the number of projects that are mainly controlled with BIM and the size of those projects. The prediction was, that the large companies that operate with larger projects are mostly operating with the BIM models as their main models. After checking the potential correlation between the variables, we saw that the correlation is not very strong. The correlation coefficient for the variables with the Slovenian data was -0.236, with the Austrian data 0174, German -0.117 and Swiss 0.125. The results are shown in

Table 9. Therefore, the usage of the BIM models in projects does not actually depend on the size of the company or the size of the projects companies are mostly operating with.

Table 9: Correlation between the size of projects and the use of BIM in companies in the DACH + SI region

Correlations

SLOVENIA			What percentage of your projects are you mainly planning with BIM?	What is the average size of the projects in your company?
Spearman's rho	What percentage of your projects are you mainly planning with BIM?	Correlation Coeff.	1.000	-0.236
		Sig. (2-tailed)	0.000	0.180
		N	35	34
	What is the average size of the projects in your company?	Correlation Coeff.	-0.236	1.000
		Sig. (2-tailed)	0.180	0.000
		N	34	42

Correlations

SWITZERLAND			What percentage of your projects are you mainly planning with BIM?	What is the average size of the projects in your company?
Spearman's rho	How many percents of your projects are you mainly planning with BIM?	Correlation Coeff.	1.000	0.125
		Sig. (2-tailed)	0.000	0.149
		N	138	134
	What is the average size of the projects in your company?	Correlation Coeff.	0.125	1.000
		Sig. (2-tailed)	0.149	0.000
		N	134	674

Correlations

GERMANY			What percentage of your projects are you mainly planning with BIM?	What is the average size of the projects in your company?
Spearman's rho	What percentage of your projects are you mainly planning with BIM?	Correlation Coeff.	1.000	-0.117
		Sig. (2-tailed)	0.000	0.536
		N	31	30
	What is the average size of the projects in your company?	Correlation Coeff.	-0.117	1.000
		Sig. (2-tailed)	0.536	0.000
		N	30	113

Correlations

AUSTRIA			What percentage of your projects are you mainly planning with BIM?	What is the average size of the projects in your company?
Spearman's rho	What percentage of your projects are you mainly planning with BIM?	Correlation Coeff.	1.000	0.174
		Sig. (2-tailed)	0.000	0.326
		N	34	34
	What is the average size of the projects in your company?	Correlation Coeff.	0.174	1.000
		Sig. (2-tailed)	0.326	0.000
		N	34	127

Next, we wanted to present the frequency of the BIM models usage in projects. The results are shown in Figure 19. From the results it can be seen that the the BIM models in projects are most frequently used in the companies where the majority of projects is worth about 10,000,000 EUR (60.0 %). The BIM models are most often used in the companies in Slovenia (23.529% of the companies are operating with the BIM models in 80–100 % of all the projects that are worth up to 10,000,000 EUR) and Germany (20.0 % of the companies are operating with the BIM models in 80–100 % of all the projects that are worth up to 10,000,000 EUR). On the other hand, the usage of the BIM models in Austria is slightly lower. Only 5.88 % of the Austrian companies are operating with the BIM models in 80–100 % of all projects that are worth up to 10,000,000 EUR and 8.82 % of projects worth up to 10,000,000 EUR are operated with the BIM models. Also in Switzerland, the frequency of operating with the BIM models worth up to 10,000,000 EUR is not very high. Only 4.48 % of all the projects are operated with the BIM models in 80–100 % and 2.24% of models in 60–80 %. Furthermore, the projects of higher values (over 10,000,000 EUR) are more often operated with the BIM models in Austria (11.674 % of all projects are operated with the BIM models in 80–100 % and 8.823 % of the projects are operated with the BIM models in 60–80 %). Switzerland is in the second place, where 3.73 % of all the projects are operated with the BIM models in 80–100 % and the same value applies for 60–80 %. The Slovenian and Austrian companies are following Switzerland. In Slovenia, 2.94 % of all the projects are operated with the BIM models in 80–100 % and in Austria, the usage of the BIM models as main models in the projects of higher values is between 6.66 % and 13.33 % in 0–60 % of all the projects. Regarding these results, we can say that the usage of the BIM models in Slovenian companies is sufficient, since the size of the companies and also the projects in Slovenia is not that large.

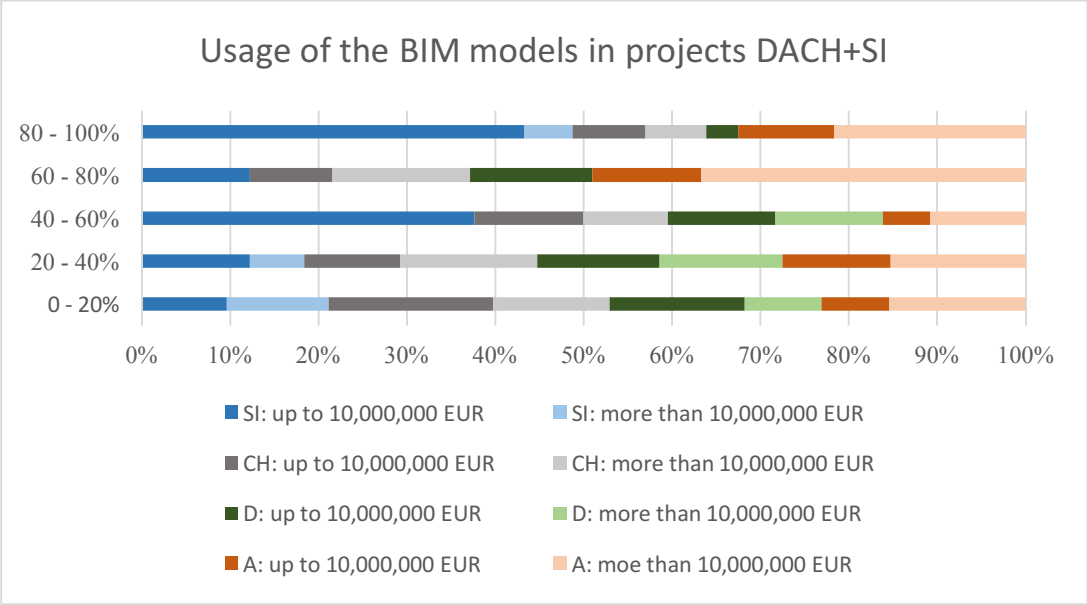

Figure 19: Usage of BIM in projects of different values for the DACH + SI region

6.2.4 Usage of BIM depending on the digitalization anchoring in the DACH + SI region

Within digitalization, different approaches in planning and modelling are available. From the 2D CAD, 3D CAD to the BIM models. Therefore, we examined whether the usage of the BIM models in projects depends on how digitalization is anchored in the company. We created a cross tabulation that is presented in Cross Table 6. For a better understanding, we created two groups: *Group 1* (participants who do not use nor know the BIM planning method) and *Group 2* (participants who know BIM well and are using it). The results showed that there is a strong relationship between the usage of BIM and digitalization anchoring in the companies in Slovenia. 70.45 % of the participants from Group 2 agreed that digitalization is well anchored in their company. On the other hand, there is no strong relation between the variables in the DACH region, only from 19.17 % (Switzerland) to 25.66 % (Germany) of the participants from Group 2 answered that digitalization is anchored in the companies they are working in. The results also showed that in Austria, Germany and Switzerland, digitalization is anchored in the companies, but the participants are not using BIM nor they know it (53.37 % of the participants from Switzerland, 55.75 % of the participants from Germany and 55.64 % of the participants from Austria in Group 1). We can thus conclude that in those companies, mostly the 2D CAD and 3D CAD planning methods are used.

Cross Table 6: Cross tabulation of the digitalization anchoring and knowing BIM

Is the topic Digitalization anchored in your company * How well do you know the BIM planning method cross Tabulation						
SLOVENIA		Group 1		Group 2		
		Count	%	Count	%	
Is the topic Digitalization anchored in your company?	No	1	2.27	3	6.81	4
	Yes	9	20.45	31	70.45	40
Total		10		34		44

Is the topic Digitalization anchored in your company * How well do you know BIM planning method Cross Tabulation						
SWITZERLAND		Group 1		Group 2		
		Count	%	Count	%	
Is the topic Digitalization anchored in your company?	No	161	24.69	18	2.76	179
	Yes	348	53.37	125	19.17	473
Total		509		143		652

Is the topic Digitalization anchored in your company * How well do you know the BIM planning method Cross Tabulation						
GERMANY		Group 1		Group 2		
		Count	%	Count	%	
Is the topic Digitalization anchored in your company?	No	18	15.93	3	2,.65	21
	Yes	63	55.75	29	25.66	92
Total		81		32		113

Is the topic Digitalization anchored in your company * How well do you know the BIM planning method Cross Tabulation						
AUSTRIA		Group 1		Group 2		
		Count	%	Count	%	
Is the topic Digitalization anchored in your company?	No	19	15.32	5	4.03	24
	Yes	69	55.64	31	25.00	100
Total		88		36		124

6.2.5 Frequency of BIM usage in addition to the costs in the DACH + SI region

Before processing the data, we predicted that the total costs in the companies have lowered because of the implementation of digitalization. The results, shown in Cross Table 7, are divided into two groups as already explained in previous subchapters: *Group 1* and *Group 2* and are showing a completely different picture as we predicted. In all four countries, the total costs have risen with the implementation of the BIM planning method in the companies. In Slovenia, 36.11 % of the participants from Group 2 answered that the costs have risen because of the implementation of digitalization, in Switzerland 10.61 %, Germany 10.61 % and Austria 13.59 %. On the other hand, approximately the same percentage of participants answered that the costs remained the same (Slovenia 30.55 %, Switzerland 9.93 %, Germany 9.71 % and Austria 6.89 %). The reason for this could be the fact that in most of those companies where participants from Group 2 answered that the costs have risen, they implemented the BIM planning method recently (in the last year). As we know, the investment costs in the first year of implementing BIM are high, especially because of the purchase of software, the education of employees, etc.

Cross Table 7: Frequency of BIM usage and costs in general for the DACH + SI region

Costs altogether* How well do you know the BIM planning method cross tabulation						
		How well do you know the BIM planning method				Total
		Group 1		Group 2		
SLOVENIA						
Costs altogether have	Risen	2	5.555	13	36.111	15
	Stayed the same	3	8.333	11	30.555	14
	Lowered	1	2.777	6	16.666	7
Total		6		30		36

Costs altogether* How well do you know the BIM planning method Cross tabulation						
		How well do you know the BIM planning method				Total
		Group 1		Group 2		
SWITZERLAND						
Costs altogether have	Risen	212	35.69	63	10.61	275
	Stayed the same	165	27.78	59	9.93	224
	Lowered	80	13.46	15	2.52	95
Total		457		137		594

Costs altogether* How well do you know the BIM planning method Cross tabulation						
		How well do you know the BIM planning method				Total
		Group 1		Group 2		
GERMANY						
Costs altogether have	Risen	41	39.81	14	13.59	55
	Stayed the same	19	18.44	10	9.71	29
	Lowered	15	14.56	4	3.88	19
Total		75		28		103

Costs altogether* How well do you know the BIM planning method Cross tabulation						
		How well do you know the BIM planning method				Total
		Group 1		Group 2		
AUSTRIA						
Costs altogether have	Risen	29	25.00	18	15.52	47
	Stayed the same	41	35.34	8	6.89	49
	Lowered	13	11.21	7	6.03	20
Total		83		33		116

6.2.6 BIM Level of the DACH + SI region companies

To conclude, we wanted to determine the BIM level of the countries in the DACH region. Therefore, we looked into how often certain planning methods are used. In Figure 20, the results are showing the percentage of the usage of the 2D, 3D CAD and BIM models in the companies in the DACH region and Slovenia and also the percentage of the implementation of a certain planning method in the future. As we wrote before, the usage of the BIM models as the main planning models in Slovenian companies is relatively high. The 57.10 % of the companies are using the BIM models as main models, also 26.90 % of the companies are often using the 4D models and in 22.50 % the 5D models. What is more, 10.60 % of Slovenian companies are

already using the 6D models as the main planning models and 50.00 % of the companies are planning to implement this planning method in the future. On the other hand, most of Swiss (55.00 %), Austrian (55.50 %) and German (60.20 %) companies are still using the 3D models as the main models. The BIM models are used as it follows: Switzerland 21.50 %, Austria 27.00 % and Germany 27.90 %. The companies in the DACH region are also starting to implement BIM into their processes on a higher BIM level. In Switzerland, 9.50 % of the companies are already working with a 4D model, 7.30 % with the 5D models and 6.60 % with the 6D models. Also, around one-quarter of Swiss companies are planning to implement the 4D, 5D and 6D models in the future. In Germany, 15.50 % of the companies are already using the 4D models as the main planning models, 16.40 % the 5D models and 10.70 % the 6D models. Between 17.50 % and 23.30 % of German companies are planning to implement the 4D, 5D and 6D BIM models into their planning processes. In Austrian companies, the situation is similar to Switzerland. 16.50 % of the companies are already working with the 4D models, 16.60 % with the 5D models and 7.80 % with the 6D models. What is more, about one-quarter of Austrian companies are planning to implement those planning models in the future.

As we described in the chapter BIM implementation phases and adoption models, the BIM Level 2 represents a collaborative work between all parties, where the parties are using their own 3D CAD model and not necessarily working on a single, shared model (BIM Level explained). Regarding this definition of BIM Level 2, we can say that most DACH + SI companies are currently in the BIM Level 2 because most of them are already using the BIM models as the main models in the planning process as well as using the 4D, 5D and 6D models in around 15 % and others are planning to implement them in the future. Therefore, we can say that most of the companies are also trying to achieve BIM Level 3, where a full collaboration between all parties is requested. The main goal of this BIM level is to achieve a collaboration of all parties in the same, shared model, to make the model available to all parties to access and modify it and eliminate the risk of conflicting information (BIM Levels explained).

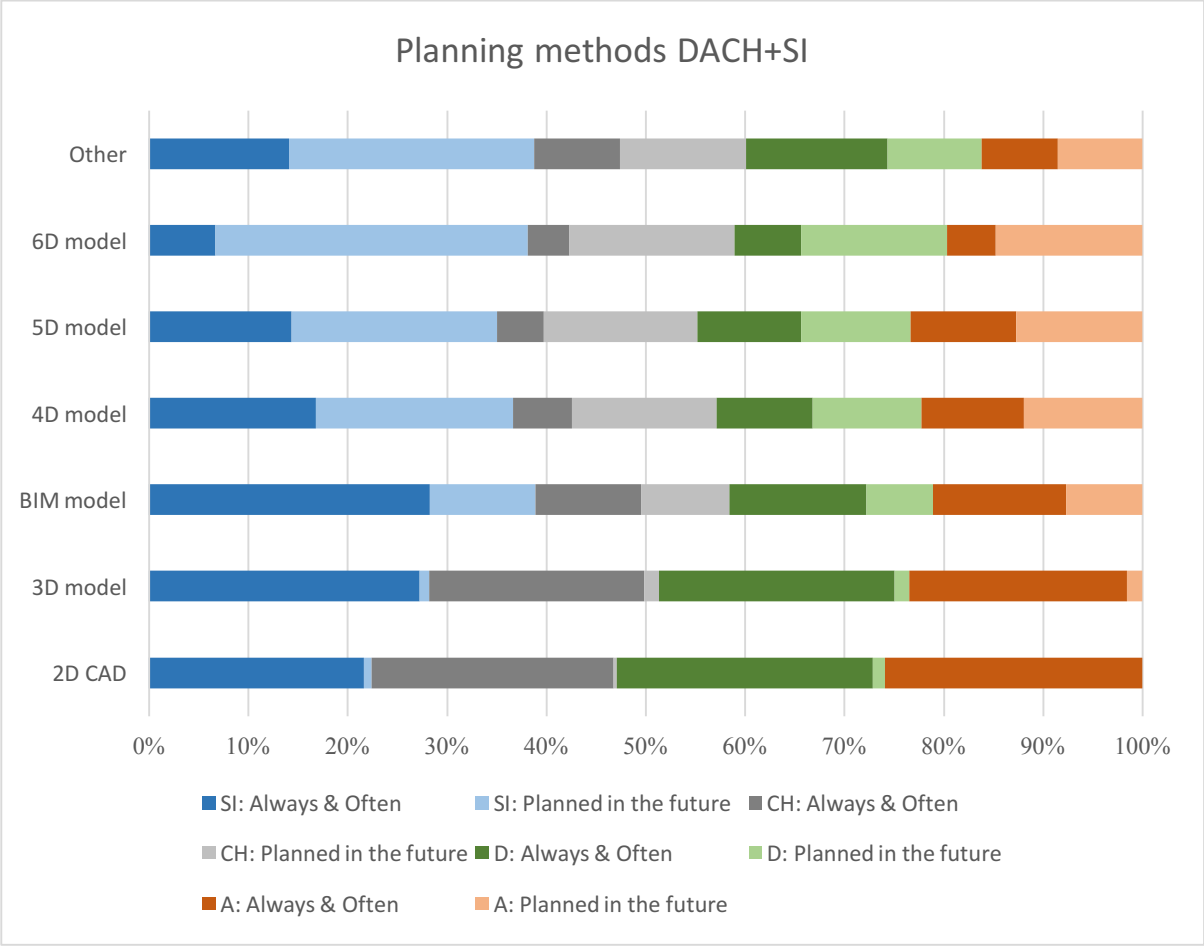

Figure 20: Planning methods DACH + SI region

7 BIM IN REAL LIFE – EXPERT INTERVIEWS

In the master thesis, we also wanted to get an insight into the position of BIM in companies from a different point of view, from the perspective of the experts who are working with BIM, developing new tools to make the use of BIM easier, more understandable and more approachable. Therefore, we conducted anonymous interviews with the BIM experts from Austria and Germany as seen in Table 10. In the interviews, which can be read in the ATTACHMENTS of the thesis, we discussed their current work, their experiences with the BIM implementation and their points of view on the actual usage and knowledge about BIM.

Table 10: Interview experts data

Expert	Age	Position	Company
E1	30–40	CEO	Computer consultant company
E2	30–40	Team leader	Construction company
E3	30–40	Head of the department	Software company
E4	50–60	CEO	Software solutions company

7.1 Offered knowledge

In the above listed companies, they are well aware of the fact that people need to be educated about BIM and that this knowledge should be affordable. Therefore, in all of these companies, they are offering software training for architects, engineers, road constructors, etc. who need and want to educate themselves about BIM or just improve their knowledge. The training offered by the computer consultant company is available on their website. One can choose between different standard courses from the BIM modelling, how to model a building, BIM project for managers, etc. It is also possible to attend special individual courses which have to be arranged separately. They are offering training for different software, such as Revit, Maya, AutoCAD and so on. The trainings are available for everyone, even for those who are meeting with BIM for the first time. They also show companies how to work together, how to take information from the construction site to the model, etc. (Expert Interview E1).

In the software company, there is also a possibility to attend one of their courses where they are offering training for different software. They also made a step forward in offering

knowledge by creating an online platform called the BIMpedia, which is accessible on the following website: https://www.bimpedia.eu/welcome. It was created with a purpose of solving technical issues and process problems that all companies are dealing with. They started 5 years ago and created a very extensive knowledge platform where all the knowledge about BIM is located. They needed 50,000 hours of developing and creating standards to put it into an online documentation system and make it accessible for the whole market. The main goal was to reach all companies, especially small companies who could never afford that sort of knowledge. They were aware of the fact that the knowledge is needed and it is available, but expensive. If we look into software trainings that are offered for architects, civil engineers and so on. one training day usually costs about 500.00 EUR, the employees are attending those trainings for about 5 days, they learn basics and after few a weeks, they forget most of it. Therefore, they decided to make it approachable and affordable for everyone. The price for a one-year access to the BIMpedia costs from 250.00 EUR onwards, depending on the number of disciplines one wants to learn and what is included (Expert Interview E3).

Within the BIMpedia, everything can be learned, from the basics we have to know when using BIM, like a storey, multi-layered walls, etc. It also includes articles, common issues when working with BIM, how to do something … The BIMpedia goes through every element that is present in the building. Every article consists of the planning stages, what is the level of detail, what are the attributes that are needed to be defined according to the standard and how can something be done in a software, from ArchiCAD, Revit, etc. It is also always updated with the novelties and updates of the standards (Expert Interview E3).

Modelling guidelines that give one a basic knowledge and also the theory of BIM are included. The biggest advantage of the BIMpedia is that one can decide which software will one use, what does one want to learn depending on one's profession and so on. Currently, the platform is only in German, but it is planned for the future to translate it into English. In addition, other standards and National annexes will be included in the future (Expert Interview E3). The BIMpedia currently takes into account the Önorm 6241 and the IFC (BIMpedia).

In the Software solutions company, mainly the program users and administrators are their usual customers attending the software training. The benefit of this training is to get to know the application and to use it efficiently in the participants' own workspaces (Expert Interview E4).

7.2 BIM improvements

In order to develop BIM further, take a step into the future, are interviewed companies trying to do so with finding new ways and approaches. We already wrote about the Property servers and the BIMpedia in the chapter **Error! Reference source not found.**, so we did not discuss this here again. However, there is so much more that can be done, and those companies are well aware of that.

7.2.1 Plugins and software integrated objects

In the computer consultant company, they are creating software integrated objects and plugins that are corresponding to the Önorm 62241 and Plangrafic when possible. For abstract objects also other, special norms are considered. Two years ago, they asked themselves what they can do to improve Revit. They decided to do something about the plugins. They started to create their own tools and modifications of the existing plugins and tools in order to improve the performance of the software, to make the users' work easier and faster.

7.2.2 Help with implementation of BIM in companies

The computer consultant company is also helping the Austrian companies who want to implement BIM into their processes to do it correctly and in the most efficient way. To do so, they are starting at the beginning. They have the so-called *implementation affirmation*, where the goal is to achieve what a company wants to achieve and what a company needs. Since they are aware of the fact that all companies are different and not all of them have the same wishes and needs, they developed some prepared packages to fulfil the desires of every company. When a certain company wants to implement BIM, this computer consultant company offers to help by starting their first pilot project. Step by step, the experts from the computer consultant company are slowly pulling back as a company is becoming more and more independent until it is completely self-standing. The output of their help is always to define how to help the company to function in the best possible way (Expert Interview E1).

7.2.3 BIM 5D and Big Room

A construction company from Austria is forcing 5D BIM into their projects, to ensure the maximum information through the outer face. Their goal is to have an enriched model where all information is given to the next face without any interruption or faces even when interacting with each other. The development of this is still facing several challenges, especially when it

comes to the construction site and bringing the model to the construction site. They already successfully implemented BIM in the planning phase, but they are looking forward to implement it also into the construction site. The problem with construction sites is that they are already working in a very optimized way. If we look at a construction site today, for example, of a skyscraper, only 5 or 6 workers are working on one floor, but around 50 years ago, the number of workers was 15–20 times bigger. That is why the acceptance of BIM at a construction site is not what we would want it to be because there, they want to know what they will gain from using BIM, how can this help them, how can they pay this, will the use of BIM models really save time, spare some money and so on. Especially small companies are facing an impossible decision and are hard to persuade to give their input into the model because of the investment costs that they cannot afford. On the other hand, clients are starting to accept the 5D BIM and are implementing it into their contracts. They also have projects in Africa, where they already work with BIM. In their opinion, this is the purpose of the whole effort that they are putting into developing and implementing BIM because that is how they can see and say that their work goes into the right direction. By implementing BIM and 5D BIM they also grant themselves the access to the new market and new clients (Expert Interview E2).

To improve the communication between the participants of the BIM projects, they also implemented the "Big Room" into their work. The idea of a Big Room was first implemented in the car industry by Toyota. The principle of the Big Room is to put all the people who are working on a project into one room, where they work together, communicate and solve problems immediately. In this construction company, they put all the people working in the design phase into a room to work together to eliminate long distance communication and create short reactions. They also implemented a hierarchy in order to track the information flow (Expert Interview E2).

7.3 Current position of BIM in Austria

To be able to understand the results of the questionnaire, we also discussed with the experts what is the position of BIM, the usage and implementation of BIM in companies from their experiences.

7.3.1 Appropriate metrics to measure BIM implementation, maturity and readiness

After talking to the experts, we realized that companies are actually mostly measuring their BIM implementation by evaluating their success in projects, how much information are they putting into the models and what are their outputs in a calculation and tender face. However, what they do not realize is that implementation, maturity and readiness of BIM are very different among companies (Expert Interview E2). On the one hand, there are companies who are saying that they have been working with BIM for a long time, but they actually have no idea what that really means and on the other hand, there are companies who want to implement BIM into their processes and have a desire for them to help them implement it. But when the experts arrive to their companies to see what is the situation and knowledge about BIM like, they are surprised because most of those companies are already working with the perfect Level 2 BIM models (Expert Interview E3)- The main difference is, in the opinion of the CEO of the Computer consultant company, whether a company has already made a BIM project or not and of course what information did they put in the model and with what kind of collaboration between the participants (Expert Interview E1). Also, the key criteria to measure the implementation of BIM is the native connection to AutoCAD and Revit and the use of web service technology to dock the existing IT world (Expert Interview E4).

7.3.2 Usage of BIM in German speaking area

In the experience of the Head of the apartment of the software company, almost every large company has already picked up on using BIM or is at least trying to do so. The problem in the German speaking area is that there is about 95 % of small companies who have less than 10 employees and around 90 % of Austrian companies with 2 employees or less. For those companies, implementing BIM represents a really large investment that they cannot afford. Because of buying software, hardware, educating employees, etc., a very big share of a market is still not using BIM (Expert Interview E3). But, the trend among the smaller companies dealing with BIM rises in order not to miss the “train” (Expert Interview E4). Also, in the opinion of the CEOs of the computer consultant company, BIM is not very known. The problem is that people, working with BIM, know simple things, like making lists of elements and rooms, but they are not capable of doing more with BIM, such as giving information from the construction site back to the model and so on (Expert Interview E1). Also, the team leader of the construction company said that they are facing a lot of problems when it comes to using BIM at the construction site. They are very advanced with BIM when it comes to the planning

process, maintenance and facility management, but the employees at the construction site are not interested in accepting and using BIM because they do not see any benefit from it. Therefore, they are working on a metric reality, the QR codes, which are printed all over their company building to show maintenance workers and technicians how their work can improve, be faster and easier when using BIM. They are working on this project now for a month and they are putting all the information about the elements, producers, maintenance intervals, etc. into a model that is accessible for people working on the maintenance phase of a building. They are also working on some new sponsor projects where they are examining the effects of a building on the environment, light, wind, emissions, cleaning of certain elements through the whole life cycle of a building and so on. With this, they want to reach the maintenance companies and show them how to save some money by making their work faster, easier and more productive (Expert Interview E2).

When it comes to the acceptance of a BIM among younger and older engineers, interviewed experts all agree that the acceptance depends on every individual. There are young engineers who are finishing their studies and know nothing about BIM, but are usually more open to learning it as older engineers who are working with CAD for years and do not want to learn anything new. On the other hand, there are also older engineers, 50 years old or more, who are very interested in learning new software and are able to learn it quickly. The problem with civil engineering is that even though people can learn software very quickly, without experiences and certain knowledge, they are making a lot of mistakes at the beginning and they also create bad models. Therefore, it is easier to teach an older engineer how to use a new BIM offering software, even though he will need more time than s younger engineer, but at the end, he will make better models with fewer mistakes. (Expert Interviews E1, E2, E3). In the construction company, they have a certain vision for the new engineers who want to work with BIM. First they have to spend 5 years on the construction site to get experiences and knowledge that they can later use in BIM in order to know what they are doing and what they are talking about, because a standard element, like a Smart Object, will not make a young, inexperienced engineer think, rather it will make him less educated. They also see the great advantage their team has due to the diversity of the team members. They have people from everywhere, not only of different ages, but also of different knowledge, which allows them to learn from each other and bring new ideas and new knowledge into the team (Expert Interview E2).

7.3.3 Average BIM level of German speaking area in companies

From the experiences of the CEO of the computer consultant company and the Head of the department of the Software company, the current BIM Level of Austrian companies is between 1 and 3 (Expert Interview E1). The problem is that there is only information about how many companies are working with the BIM offering software, but there is no information about the details put into the models. Furthermore, everyone is basically using the 3D models and CAD with very basic workflows. On the other hand, there are about 15–20 % of big companies that are working with BIM and some architecture studios that are making the perfect BIM Level 3 models and do not even know about them, because they are using software like Revit or Archicad. In the German speaking area, there are also many people who are working with the BIM tools, but most of them are not aware of the profits they can get out of them and what they really are, especially on the BIM Level 3 (Expert Interview E3).

7.3.4 What can be done to improve the usage of BIM in companies

As far as BIM is concerned, it is used more and more often without a very good knowledge about what it really is and what it can offer, the most appropriate thing right now would be to offer an inexpensive and valuable knowledge to all the people working with it. Therefore, the Software company created an online platform, called the BIMpedia (Expert Interview E3), to offer knowledge to all, especially small companies who do not have resources to afford it otherwise. In order to work with BIM and deliver it properly, efficiently and in an exact manner, the international standards should be made and implemented into the property servers, Smart Objects, etc. BIM has to get deeper into the education system, especially in technical schools and technical colleges because there is still a lack of well-trained experts for BIM (Expert Interview E4). Companies also have to develop and learn how to work together (Expert Interview E1) – all project members should work on the same standards and norms, communication should be more fluent and faster and the BIM models have to be implemented into construction sites where information has to be delivered to the offices' model constantly in order to make a step forward and bring companies to the next BIM Level. Companies should develop tools, offer training, help to implement BIM, etc., and constantly educate their employees, search for new opportunities, improvements and solutions regarding BIM.

8 HOW TO IMPROVE BIM EFFICIENCY THROUGH BIM BENEFITS?

Throughout the thesis, we wrote about different benefits of using BIM and implementing it into a company, project, team, etc. Within a careful examination of the available literature, we found out how BIM can really help us in our everyday construction, architecture, maintenance, etc. and also proposed some suggestions how to improve the efficiency of BIM through the BIM benefits.

Within the research, we found out that the most lucrative benefits of using BIM are reducing the errors in all project phases, which saves money and time with elimination of rework, improved collaboration within all parties, which leads to faster communication, faster registration of possible errors and their elimination and also that with the optimisation of building efficiency, we are able to provide more sustainable designs and positively influence the environment with the reduction of waste during the construction process.

Even though BIM is developing fast and is getting more and more accepted between investors, engineers, architects, etc. and is with its benefits improving architecture and construction engineering in a many ways, there are still possibilities to move forward and to make an even larger impact on the efficiency through the BIM benefits. Within the research, we discovered that BIM is known among many, but there is still a large number of those who are not aware of it nor do they know what it really means. Therefore, we think that it is of great value that we make the BIM knowledge available and affordable to everyone, which means that not only large companies would be able to afford the BIM education of their employees, the implementation of BIM into the company and using BIM, but that this would be affordable for small companies as well. If we want to achieve the next BIM levels (e.g. BIM Level 3 and above), we have to take into account that small companies will also have to come on board and start using BIM.

Secondly, we believe that the BIM efficiency can be improved with better compatibility among the BIM software. As we know, the IFC has to be compatible with the programs we are working with, and there should not be any errors and loss of information or the project properties when we are importing the IFC from one software to another. What is more, BIM efficiency can also be improved with guidelines and standards that would be valid at least for the countries of the European Union area, because then we can eliminate all of the disagreements and make the BIM process unique and compatible through the whole Europe. This mean that projects would not depend on a language or a country and we would be able to work borderless. This could

also represent a potential for companies to enter a foreign market more easily, be concurrent foreign companies and win more projects.

9 CONCLUSION

In the master thesis, we made a research about the usage, implementation and challenges of BIM in Slovenia, Austria, Germany and Switzerland. The purpose of the thesis was to compare the results regarding BIM between the countries and present some suggestions of the possibilities to make BIM more known, used and successful among the companies.

The results of the research were collected with a questionnaire that was sent to different companies and experts working with BIM in Slovenia, Austria, Germany and Switzerland, where we checked the correlations between different variables, using Spearman's' rank correlation. Within the research, expert interviews with the CEOs, the Head of the department and the Team leader from different companies in Austria and Germany were made to get a better insight on the actual usage of BIM, its challenges and developments. The results that we got from the questionnaire showed us that there is no strong influence of the implementation of BIM on the costs, the reason for which is that most of the companies that were participating in the survey implemented BIM about 1 year ago, when investments were the biggest. Furthermore, we discovered that there is a significant correlation between the age of civil engineers and the knowledge about BIM. Younger engineers tend to know BIM better than older in Slovenia and Austria and vice versa in Germany and Switzerland, but from the experiences of the interviewed experts, some older engineers are also curious to learn the new BIM offering software and work in a BIM way.

Next, we discovered that there is no strong connection between the number of projects that are controlled with BIM and the size of those projects. On the other hand, however, large companies tend to operate with more BIM projects since it is easier for them to implement BIM because their income is larger, the resources are easier to create and the number of the potential BIM projects is greater. Within the research, we discovered that in the Slovenian companies in which the digitalization is anchored, BIM is more often used. On the other hand, in the companies in the DACH region, this correlation is weak, since most companies mostly use the 2D CAD and 3D CAD planning methods.

Lastly, we wanted to determine the average BIM Level of the companies in the mentioned countries. From the interviews we saw that the BIM Level in the DACH region varies and is between Level 1 and Level 3, where small companies are mostly in the BIM Level 1 and large in Level 3. From the results of the questionnaire we also concluded that the average BIM Level of Slovenian companies is Level 2 since 57.10 % of the companies are using the BIM models

as the main models and 26.90 % of the companies are already working with the 4D models and 22.50 % with the 5D models.

Within the research, we also found out that the leader in BIM using is Slovenia, but we are aware that the sample of the participants in the questionnaire consisted mostly of the BIM experts, therefore, the knowledge and usage of BIM among those is higher.

Obstacles to the BIM implementation in the DACH + SI region for the past few years were the following: the economic crisis, which prevented a great amount of new projects, the unemployment, the struggling of smaller companies to survive in the very competitive market, bankruptcy of several companies, clients also did not demand BIM in their orders, the investment costs of implementing BIM also present one of the most important reasons why companies do not decide to implement BIM, some of the smaller companies and contractors are not open to technological changes, the lack of experts and BIM knowledge, the lack of business ambition, etc.

When we evaluated the data we received from the questionnaire, we discovered that the questionnaire was too extensive for our research and therefore many participants did not finish the questionnaire. For the future work it would be wise to adjust the questionnaire with fewer questions, focusing only on the exact topics we want to research., It would also be of great value if a similar research would be made in 5 years, where the influence of the BIM implementation on the costs should be checked in order to evaluate if implementing BIM has a positive effect on the costs after a few years.

Hypotheses for the whole DACH + SI region were:

- **1. Hypothesis: In the companies in which new methods were implemented, digitalisation created new income.**
- **2. Hypothesis: The usage of BIM is higher among younger engineers.**
- **3. Hypothesis: Large companies operate with more BIM projects.**
- **4. Hypothesis: The companies who anchored the digitalisation are also using BIM.**
- **5. Hypothesis: The more often that companies use BIM, the lower are the costs.**
- **6. Hypothesis: More than half of Slovenian companies are currently in the BIM Level 2.**
- **7. Hypothesis: More than half of the companies in the DACH region are currently in the BIM Level 2.**

Within the research we were able to confirm the first, sixth and seventh hypothesis, others were disproved.

Key findings of the thesis were:

- **Implementation of BIM does not have a great influence on the costs in the companies in which BIM was implemented less than one year ago.**
- **Younger engineers in Slovenia and Austria tend to know and use BIM more than older.**
- **In Switzerland and Germany, BIM is better known among older engineers.**
- **Large companies tend to operate with more BIM projects because the implementation of BIM is easier from the point of resources and costs.**
- **In Slovenian companies, BIM is more often used where the digitalisation is anchored.**
- **In the companies of the DACH region, mostly the 2D CAD and 3D CAD planning methods are used where the digitalisation is anchored.**
- **The average BIM Level in Slovenia is Level 2.**
- **The average BIM Level of the DACH region is between Level 1 and Level 2.**

10 LITERATURE

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11 ATTACHMENTS

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11.4 Expert Interview E1: CEO, Computer consultant company

- **For which software are you offering trainings focused on BIM and to whom are those trainings mainly dedicated?**

  The main software we are using is Revit. We are software independent and are currently building up the trainings (90% of the trainings are in Revit). We also have trainings in connection with software different than Revit (e.g. connections with Rhino, AutoCAD, Maya, …). But the main modelling work is focused on Revit.

- **In which way are you supporting planning offices and what are the challenges in this sort of support?**

  When the company wants to implement BIM, we start right at the beginning. We have the so-called implementation affirmation and we see what the goal of the company is, what they want to achieve, what the company needs. We have prepared packages and then we chose which package is the best for a certain company, depending on their needs. We also have software trainings. We also have adjustments of objects with which the company can start a pilot project with our help. When the company starts to get into the process, we start to take steps back slowly (step by step), so that the company is more and more self-standing and independent. We still make special checks of the models or maintenance of the BIM model or server until we know that the company is completely self-standing. The output of our help is always to define how to help the company to function in the best possible way.

- **You are creating software integrated objects that correspond to the Austrian standard. Can you tell me more about this (which standards do you have to take into account, what are the challenges in creating those objects, advantages and maybe disadvantages)?**

  We are developing Revit BIM objects. We are trying to fulfil the Önorm 62241 when this is possible. What we also try to fulfil is the Plangrafik (die plan bestellung die BIM objekte). The BIM norm is important for the systematization of parameters, there are also some special norms for the execution of abstract objects.

- **What is your server?**

We are hosting on a server in a Vienna computer centre and on this server, a Revit (Autodesk) server is installed, different planning companies are working together on this Revit server. This is a central data (architects and bearing planners are working in this central database together). This is an infrastructure for connecting both parties. Different people can work on the same projects.

- **You are also researching software plugins. What is the goal of this research? For which software are you doing researches? Are the results of those researches available for other BIM users and how can the results influence the BIM usage?**
  Two years ago, we were trying to find a way how we can improve Revit, so we decided we should look into plugins. We found many possibilities and we are therefore making our own tools and tools for the customers. But those are not plugins, but modifications. We also want to go in the direction of big project software development. And yes, of course, those plugins are available to all users.

- **What do you think are the most appropriate metrics to measure the BIM implementation, maturity and readiness?**
  We have different experiences. We have companies who have no idea what BIM is but are already working very BIM-like (already have the information about the elements in the model …). And we also have companies who are saying they have been working with BIM for a long time, but they actually have no idea what that really means. The main difference for me is whether a company has already made a BIM project or not. And, of course, also other important steps: how many information were in the model and what was the collaboration between the participants.

- **What is from your experiences the usage of BIM like in the companies? Is BIM better accepted among younger or older engineers? Do you think that BIM is more likely to be used in large companies?**
  I think that BIM is not very well-known. Because, for example, those simple things such as a list of doors or a list of rooms are easy for people to do and use. But the more difficult things for most of the companies are to give the information from construction site back to the model. Also, the reason for this is that planning partners are not using

the software and there is a lot of potential for working together, which needs to be developed.

I think younger engineers know BIM better, but there are also groups in our trainings for example (50+) that can understand the software and BIM very quickly and are also faster than 25-year-olds. There are also exceptions who have this attitude when they do not want to learn the software because they are used to the old one (e.g. I have 20 years of experiences with AutoCAD and I don't want to learn anything new).

The usage of BIM is very different in companies. BIM is a big standardization and when it is needed, it is easier for large companies to implement it and define the resources that they need, and in a small company this is harder, especially because if 2 people need to learn the software and are spending every week two hours of work for it, this is a big loss for the company in large companies this is not a big deal. But I also think this is a great opportunity for small companies because then they can work more together.

- **Do you think that there is a significant connection between how digitalization is anchored in the company and how well BIM is known?**

  I think both are management decisions and I think if there is digitalization in the company, there is also BIM.

- **What is from your experience the average BIM level of companies?**

  I think from 1 to 3. There are projects where only two people are working on a common project and are very pragmatic. Our goal is to achieve Level 3 or 4. We are currently focused on Level 3. But I cannot really say, because it is very different and divided right now.

- **What should still be done to improve the usage of BIM in companies and projects?**

  I think the important thing is to see the process changes and the organization of the resources and also the relief of plans. The companies have to develop and work together.

- **What are your goals for the future regarding BIM?**

  We are constantly researching what is new on the market, what are the new possibilities, what are the new technologies, new methods to use, how to develop the BIM method further. So this is also what we will do in the future.

- **How well is BIM implemented in your company? (How often is BIM used as a main model in projects, how well are the employees educated, are you continuously educating your employees …)?**

  We are constantly educating our employees, we have the intern trainee programs for our employees, we always look for solutions when someone has a question or a problem, we also have specialists for certain topics, we are always looking for the solution inside of the company.

- **You said you are offering trainings for others. You are offering trainings for the software? For whom (architects, engineers, companies?)**

  We offer trainings for architects, also for road constructors, building constructors, we also have companies for house technic and we also show people how to implement certain information in a model. But we are also organising trainings for all who need to learn how to make a kitchen plan for example, we also show companies how to work together, how to take information from the construction site to the model and we also have workshops for making concepts of the projects (how to use BIM). Also, we offer different workshops, such as what is BIM, what are advantages of BIM …

- **Can anyone apply for these trainings?**

  We have a website and all of our trainings are listed there (standard trainings: BIM modelling, for those who are working with Revit for the first time, how to model a building, the classical things that companies need from the beginning, BIM for project managers). We also have special individual trainings. Those have to be arranged separately.

11.5 Expert Interview E2: Team leader, Construction company

- **What are the most important features of BIM 5D?**

The problems we are facing with BIM is explaining the whole life cycle of it, and I think what companies are trying to do right now is to focus on very specified faces. We cannot cover the entire overview, so we are just pointing out very specified elements out of the whole planning process. And I think that maybe the main goal is to reduce the interfaces in

between different software programs that we are using and having right now. So the idea of BIM 5D is actually to ensure the maximum information through the outer face (I think this is the main goal of BIM, because we were working on 2D plans, talking on the phone to each other and now we are capable of saving most of the data in the so-called data model and the goal is to have this data model really enriched from face to face and all the information is given to the next face without any interruption or even the faces interacting to each other, there is no clear border anymore, so we get ripped of the information loss in general).

- **Where there any challenges with the development and implementation of BIM 5D in the company? Is it accepted among the employees or are they struggling?**

There are still, actually. I think it depends on what faces we are talking about. Right now, we have implemented BIM mainly in the planning phase. We have already started with digital drawing methods or tools; I mean it is nothing new. We already started with this in the 80s. We have already worked with the X-ray for a long time, and we are trying to establish collaborative working methods. And now, we are bringing up something new, we try to call it BIM and it will revolutionize everything, but at the end, it is still not a process, it is done step by step, I would say. So we are actually confusing our employees by telling them now we are having a new working method called BIM and you have to change the workflow and everything will be transparent and will be seen and, of course, the first thing you create is actually fear and sort of chaos. And the problem is also that people think now that we have created something for them, which can make their lives or working processes easier, so that they can actually relax and press the button and everything can be done. However, at the end, it is a totally different thing we are looking at. So is it easier for an employee or is it easier for it to reach the employees? Let us say that in the planning phase, is more or less accepted. People have been working with models for a long time, and it is not something that they would not been doing by now. The only thing that they are doing now and they are not used to is that now we have different partners. Maybe the landlord has a little more interest in what is going on and he is able to see the model and plans and look into them. Maybe what is also something new is that the facility manager is already there in the planning face. This did not happen until now. But, at the end, they are all dealing with the same thing. The big gap that we are facing right now is to bring the model on the construction site. There, they do not really see the benefit. They are already working in a

very optimized way. I mean, if you look at the construction site today (.e.g. Skyscraper) on the one floor, there are maybe 5 to 6 workers, and 50 years ago there were about 100 of them. So it is very, very optimized. That is why at the construction site, they are asking: "What is in this model that can help me? Is it that I can see everything 3D or three dimensional? But on the other hand, I am able to read a plan. So why do I need the whole thing for? It does not make it faster. I actually have to employ my people, get the software and this costs money. So who will pay for this? And my calculations are already very though." Especially for a small company. And even in a large scale company as are we , it is very hard to persuade the people on the construction site to give their input and say this is what we want from them (their input) because we did not reach the stage of having a model on the construction site and everybody can play with this model and get information out of it. This is still under construction. There is nothing really given and actually what an operative wants is this button pressed tool that makes their life easier. Those are actually the main problems that we are having. So it is really still not very accepted as a change of culture and at the end, we also do not want to say to them that everything is going to change. The goal is to focus on the small processes that are making their lives easier. If you take for example a site engineer: Today he has to deal with everything. He has to deal with the budget with the workers, with official people, with the intern hierarchy, which he has to report to, he is doing a lot of things. Before that, he was the one who needed to go to the site, to check if everything was done according to the plan, and nowadays he has no time for that. And maybe there is a possibility to shorten the workflows or to have a consistent delivery of information and he can immediately see what is happening, without asking and wanting a report or waiting for it. He can see this on one platform. Maybe this would not bring him back to the site, but he will have an overview over everything what is happening on the construction site. There are many more things that they have to look after, but at least they have some sort of information on what is going on.
This is a possibility of dealing with BIM as an information platform.

- **Are you satisfied with the outcome and did the BIM implementation create a new income and grant you an access to the new market and new clients?**

Of course. I mean, as a large company, we can afford having a department as we do right now. Our department consist altogether of 50 people (40 people are working in Stuttgart, 10 in Vienna). In Vienna, we are mostly focused on developing a building catalogue

according to the Austrian standards. Vienna is also like a hub to the East and of course we have many partners in the East who are interested in what is going on in digitalization and we are developing with them together as well. And of course it creates more income or let us say more money in that sense that we have people who are now working with the issue that was not there before. In my team there is 10 people (not all of us are new in this company, most of us have already worked here for a couple of years, but we have also been at the construction site, myself working as an architect and we were all working in a completely different field, we also have younger people – IT specialists). Of course, this needs to be paid. Right now, the issue is who is paying for this. Does the project really make money for the BIM development? To be honest, no. It costs more money. It is said that everything is more effective, more optimized. To be honest, we are working on the optimization and on standardization of things. But this is development. We are producing tools which can be used by operatives, but are not functional in a BIM sense, the life cycle sense. Again, we are very focused on specific faces. Or even in these faces, when we are talking about a planning face, of course we can now make a model in certain detail (we can make a model at the beginning with LOD 200, LOD 300 and we can make plans out of it, we can connect it to a calculation program and we can generate a price out of it for tender face). But for planning this is not all. We have so many participants. One of our greatest issues right now is the central model – that means that we have different participants or partners and in the best case they are all inside of the company (meaning we have to work with one or two programs which would be an optimum of what can happen for us because we are right now doing the closed BIM). But the problem is that we have so many different partners in the projects and many of them are external and many of them are working with different programs and therefore, it is hard or almost impossible to gather together all the information. In this sense, it is not really combinable. So most of our work is also to find a work around. Because BIM is not working the way it should. So we have to be very innovative in bringing together the data. And again, the data was not there before. Everyone thinks that if you optimize and make things more effective that this brings you money. That we can get more money out of a project, we can be faster in carrying out our project, but in the end we have so much input, such a flow of information which was not there before and this data we have to collect (collecting itself is not that difficult, but to get the right data to the right people and to filter this data, this is a very important task). Behind this process, there are so many different processes that no one knows about. The data you are getting is

also only working in one software or, better said, in the software which is produced for that workflow. For instance, for planning, we are using the planning software (in our case Revit), calculation is ITU, if we go to the construction site and we take the model on the iPad, then we have a totally different software program, and when we want to change something in the model in the iPads' software (e.g. we want to change a parameter), we cannot bring the data back to the model. But we need this. The idea is to collaborate on one model. But at the end, you have so many different data in different models which needs to be put together. We need to achieve compatibility among different programs. But software developers are not opening their source codes. This is their profit. Autodesk, for example, says we have a new program and we can make an IFC out of it and you can transfer it into every other software program. It is true, you can make an IFC out of it, but that does not mean that different software can read it as Autodesk and what was exported. We are also working with Allplan and when we are transporting information with the IFC from Revit to Allplan, we can see that geometry is different, some of the parameters are lost, their position is not there, some of them have a different name … so there is no consistency and this is what software development companies actually do, they do not want an open source. They have a product they want to sell. And we are very dependent on them. You know data is the new oil and companies want to keep the containers in which the oil is stored.

- **How is BIM 5D accepted among clients? Are they happy about it?**

It is slowly starting to be accepted. Now we already have some clients who have BIM implemented in their contract. It does not mean that they know what they want, but they have heard about it somewhere or they even have a BIM manager who is telling them this is the information you can get. We have projects in Africa, where we already worked with BIM (where BIM was required by a client). This gives our development a purpose because you see that it does not go in the wrong direction. This represents new opportunities and it is worth it. So among the clients it depends on a client, actually. Not every client is interested in building something, but they are mostly interested in selling it. So this is also the problem with the philosophy of BIM. Because it stops at a certain point. The client will not invest money in parameters which are needed for the maintenance. What for? He wants to have a building and he wants it to be build fast and cheap and to be sold for a lot of money. We have to maybe create a value by telling them: you can sell it for even more money if you have those parameters. I mean it is all about the money. Of course BIM has a higher reason

of sustainability and you know what you are building and you know the materials, even when you tear it down again, you can put it in different containers or resources. Of course, there is a great philosophy behind it, but at the end, the market is about money. But we have to be optimistic. I think this is also slightly changing, for instance. we can observe this if we compare people working with BIM (most of them are young people, of course we also have older people (we have a guy who is 46 and he is the most flexible guy and he is learning programs like nothing, he is interested in learning new things, and we can learn a lot from him because he has a lot of experience)). What is more, other people also feel some sort of a change, and for a construction company this is something very special. Because construction is a very rigid, very conservative industry. We have been doing this already for the past 60 years or even longer. Construction itself for 1000 of years. It is putting one brick over another. People are asking why should I change my workflow? But what I sense here is that people are very enthusiastic about what is happening. They want a better world. I know this sounds kind of naïve. Because we know how construction industry works: putting money from one pocket to another. However, being a BIM team is of course somewhat different because I see ourselves as a speed boat in front of a tanker. The problem we are having is that we are still chained on this big tanker. We cannot move that much, but we can be at least a little bit more in the front. I also know what happens with a speed boat: it goes up and down a lot of times and it costs a lot of energy, but at the end, it seems that the company realized it makes sense to have that sort of a team: small, very agile team, which of course has to have very precisely defined goals and in the end, it is about bringing our innovation to the construction site. Because this is where we are making money.

- **How often is BIM 5D used as the main planning model in your projects?**

We have been working with BIM for a long time. We started in 2002. Of course, at first it was just an idea that was taken from the car industry that was already using this sort of collaboration a long time before, also the plane industry, the IT. Construction industry is in the back, but okay, we are catching up. It started a long time ago with an idea and in 2006, we started with the pilot project and up until today we have carried out a lot of projects. We have already made around 600 projects (but to be honest you cannot call them the BIM projects. It is putting the data into a different field). But we were told by our managing board 1.5 or 2 years ago that every project that exceeds 20 million should be done in BIM. What they understand under BIM is that we are doing a model with our building catalogue

and we can put the elements according to the bill of quantity. And that we can get the quantity out of it and the price. This should be done, but at the end it is not like that. Right now, we are working in BIG ROOM. Big Room was an innovation of the car industry in the 80s by Toyota. And what they said was that during the design phase, all of the participants should be stuck into one room. Put them in one room to work together. We took this idea and implemented it into construction industry. I do not know how other companies are dealing with this, but I think that it is also done in several other companies. What are we doing putting architects, structural engineers and so on into a room. And even if there were external partners, they should also sit in there. So the long distance communication is not there anymore. You can have short reactions. Right now, they are actually working on the same central model. All of them. If there are some issues, we have a BIG screen and they can put the problem on the screen and then they discuss it all together.

This enables better efficiency, everybody is informed at the same time. You do not have to worry about sending the emails or something.

Another problem that came up during this project is that this short distance communication led to non-documentation. So if anyone had a problem, he was just shouting over the room, people were working together on the problem and at the end no one really knew who actually ordered and said that there was a problem, who solved the problem etc. At the end, we could not track the information flow anymore. Therefore, we had to implement a certain hierarchy how to proceed in case of a problem. There has to be a name that is telling someone what to do, until when. So it is not chaotic.

- **Do you have any instructions / advice for other companies that are struggling with the implementation of BIM?**

Actually, many people are asking me this question. If I would be a small company, I would let the large companies do their thing and wait for the right moment. Most of my friends have their own small architecture office or they are working in an architecture company. For them, right now, BIM is not really useful. It depends on the project skills that they are dealing with. If you have a family house or some other small building, then you are very restricted by the law and normatives (of course bigger companies are too). The normatives are written in a very imprecise or precise way, depends on how you look at it, and you have to follow these steps. And I think that normatives should be the first that need to bring digital structure into Merksmalsserver. This is actually what they are doing. Right now they are

putting up this Merkmalsserver that is about a structure for materials and workflows. If small companies now try to develop a standard or a company standard, then they have to invest many resources into that and at the end it can change in one month or one year. So actually all thework that they have done is almost for nothing. Large companies can deal with that because for example, we have been developing a catalogue according to Leistungsbeschreibung Hochbau (LBH) for the last 1.5 year. If we look now into a building catalogue out of a model, then it is totally different. You do not need to have this trade wise structure. In a model everything is connected. Therefore, for us, if we take the building catalogue out of a model, it would look totally different. It will be more interactive; it does not make sense to have it in such a rigid system. But, of course, what we are also doing is preparing ourselves for the future, so that we will know how to deal with programs, with what is on the market. I suggest that small companies should just keep their eyes open. I mean they are already digitalizing, they are working with CAD programs, they are working with model making programs. It is not that they do not know anything about BIM, they are doing it actually already. And they are also giving parameters (more than just geometrical parameters). I think it just needs to be done step by step and follow and see what the normatives are doing (actually they are moving quite fast – as much as a normative can).

- **Which software is mostly used in your projects?**

We are mostly using Revit, but also Allplan for calculation.

It is obligatory to use Revit because of the interfaces. We need to reduce all these problems and unfortunately there is no other way (in civil construction we are using Revit and ITU and in road construction we are using many other programs, because Revit has no possibility for the terrain). Some people are working with Revit and are trying to make a catalogue out of it. Also in road construction, with Revit is very hard to model topography and connect topography with bridges. Therefore, we make bridges in Revit and topography in other programs. Revt It is not possible to create shapes with Revit and it is too difficult. At the end, we have to think about the open BIM and we have to be open to more software programs and we have to find a solution how to get the information from one to another.

- **What do you think are the most appropriate metrics to measure BIM implementation, maturity and readiness?**

The main problems we are dealing with are housing buildings, office buildings, industrial buildings, road construction. So, our projects are not Zaha Hadid projects or something like that. I mean we have these sort of projects as well, right now we have Axel Springer project in Berlin. Those are prototypes, there is only one building like that. But for the housing it is repetitive and with a building catalogue we can cover let us say 70 % of this building. Actually, what we are really measuring right now and how far we are in BIM is what is our output in our calculation in a tender face. Again, this is a very narrow street. And of course it is very dependable on the willingness of the operatives, so of course we want to bring this benefit of a model to the construction site and there are very few pilot projects going on where we have a possibility of making or gathering the knowledge about how the model is really accepted at the construction site. But what is very intense right now being the collaboration with our facility managers and they are very interested in this development. Right now, for example, we are doing metric reality for them. As you can see we have those QR codes everywhere and we can see underneath the ceiling, so it is a benefit for them, for the technicians when they are coming in the building and they want to maintain a certain part, they know where to open for instance. the ceiling. This is currently under development, but very good. We have been working on this now for a month and we have a year to present to them how this works. It is not only that you can for example see inside the ceiling, but you can also maybe point out the element you want to see and you can see the parameters of this element, who is the producer, what are the maintenance intervals, how long is the constructional usage… We also want to connect this to all sorts of documents. So you can link it to the maintenance document, you can just click digitally on your tablet or something and you can automatically put it on the server, so there is no more paper work. What we want is to make it more efficient. And if you consider the building costs of the whole life cycle, then 80 % is in the maintenance and only 20 % is in the beginning. So for maintenance workers, if they spare 5 minutes by opening the right part or something, or even finding the right part and if you have e.g. 200 buildings, you can spare a lot of time in one year and also a lot of money. We are also working on some new sponsor projects, one of them is embedded here and is mainly about a building embedded into the surrounding, what sort of an effect does the building have on other buildings, on the environment, concerning emissions, light, wind, but also internal parameters. What we also did was we measured the output of the cleaning of floors through the whole life cycle, the cleaning of the windows, how many people or hours need to be spent, when must a certain task to be done, how often

do we need to pain a wall… This is really put into a model, you click on a wall and then you can see that you have to paint it every 10 years or so. It can maybe also pop out for the maintenance company, they know this wall was not repainted in 10 years, now they need to do it. And this is the information that you have in the model all the time. Also what are the consumptions we are dealing with (toilets, how much water is produced …)

- **What do you think the usage of BIM is like in other companies in Austria?**

Actually, we are all cooking with water, this is what used to be said. The BIM community is a very small one, especially in Vienna. Most of the interaction happens in Vienna and when you are invited to various seminars and presentations, there are always the same people sitting there and we are always discussing the same things, problems. So I think in the large companies we are ahead in terms of BIM in the planning process and also in getting out the quantities and the costs as well as in terms of construction. I think Porr is quite good, because their CEO is a bit stricter than ours. Ours is more liberal, they tell us: ok, as long as you do not make any deficit, you can do whatever you want. But in Porr they say: ok, everything has to be BIM, you have to change your planning platform, you have to bring the tablet and software to the construction site. So I think they are forcing it a lot. In terms of construction, I think Porr may be ahead of us. In terms of maintenance and facility management I think we are also the ones who are putting a lot of effort into that. And maybe also in finding a new way of working. Again, in this team, we have no hierarchy, we try to take small projects and bring them to an end. We try to be very flexible and agile; we are using methods which are used in the IT or also in the Silicon Valley. And we also have this area where we invite our guests, where we present our projects to our clients, we are doing our meetings here, we want to show them what we are working on, the big room, we also have our video conferences here. So everything is very closely connected and we are trying to exchange information. This is our main goal. We also have to make it visible, especially in such a big company. So among everyone that are passing by, sometimes someone is interested and stops, listens, just to offer a possibility to learn something new, to have new ideas, to add something, to say something. This is nothing usual, but it is our way in which we think our work can be seen differently. I think this is what needs to be changed. It is not all about putting the data into a computer, there is much more behind this.

- **Do you think BIM is better accepted among younger or older engineers?**

Of course there are digital natives which have a certain easiness in getting along with the digital things. It is really easy for them to swipe, to get the information out of a program, to deal with a tool. The problem is only that in construction, we also need experienced people. When you look at what we want to achieve to create standards, there is a problem when the standards are used for the people who do not know the surrounding of it. So you can employ a 22-year-old person who just finished the University and you put them on calculation or modelling and you say to them: no worries, you cannot make any mistakes, we have our standards, you just have to follow them and use them. It is not about using the standard and not changing it or not adjusting it, there are so many things you need to have experiences with. What we are saying is before you come into a BIM team, you have to spend 5 years at the construction site, so you know what you are talking about, you know what you are dealing with. A standard element will not make you think; it can even make you more stupid. So I would say that the acceptance of the tool or software itself is very easy to explain to a young person and very difficult to explain to older person. Maybe the older one actually needs more time to use it and younger one can do it immediately. But the effect will be that the young one will make so many mistakes and bad projects out of it and on the other hand, the older one will maybe need more time at the beginning, but the output will be correct. The best thing about our team is that we have people from everywhere; not only of different ages but also of different knowledge, education. If you have a diverse team, I think this is a really good combination.

- **Do you think that BIM is more likely to be used in larger companies than smaller?**

Yes, just because of the costs. You have the software, the resources, the training of the people, the development. BIM is nothing fixed. But we will try to give an extraordinary name to the whole process. The goal is to not be talking about BIM anymore. BIM is integrated in the workflow. We are also not talking about using the CAD system, we just say that we are drawing plans, for instance. The same thing is with BIM. Right now, large companies have money to develop or just to search, but when it will become more open and more free, I think people will like it. Even when I look at my friends, they are always like: Oh, my God, what are you doing, as an architect you are destroying our creativity and then I explain to them: the model you just did in Rhino and you spent 2 days just to get the quantity out of the model and put it into a bill of quantity, I can do that in maybe half a day. And they are always like: really, this is what you are doing? Okay, this could help me, but

the other things I do not want. At the end, creativity does not disappear. You can be creative as much as you want, you can make forms or whatever. But people are very afraid of the law and normative, because they think that it is making them more watchable, more transparent. This is what they are fearing, that everything is so transparent and everyone can look into numbers and into the design that you are doing, also the landlord can at all times look into it and this makes our people afraid of sharing the information.

11.6 Expert Interview E3: Head of the department, Software company

- **What is the Property Server (PS) and for whom is it designed?**

  That is probably the easiest question. The property server means having an international data sets like the IFC or Building smart dictionary (BSD) and what we did was we took the object description from the IFC and BSD and also different properties for objects from the BSD standard (such as windows, walls, …). What the property server does is set a project stage where the information has to be defined. For instance, a fire railing of the wall is in Austria a predesign stage, you have to define it, and the property server puts a number of the planning stage (which is 2.1, 2.2, 2.3, …) next to the property. At the current stage of the development, it is a graph database and the interface is really chaotic and no one can really use it and understand, therefore, we are currently working on the so-called Property server 2.0, where we try to implement an interface to make it more approachable and understandable for the users. It is a very basic idea: put the planning stage next to a property. When you try to use the property server, you cannot really understand it, it is currently slightly complicated. Also, we have 80 or 85 % of the properties that are needed for the planning procedure for a building but for example the whole hfac world and lmp elements are not on the server yet. We are currently in the middle of a research project called the Free BIM 2. The Free BIM 1 made the Property server 1.0, and in the Free BIM 2 we are making the Property server 2.0, to develop a leaner and understandable interface and to implement the imp parameters.

- **What are the advantages and disadvantages of the PS and how is the PS accepted among the experts?**

  There is this international way of standardizing BIM, where you have a level of information and a level of detail and there is the level of information 300, but no one

actually knows what is inside of this level. And the big advantage of the Property server is, that you know really precisely, down to the attributes of an element, what planning stage, which information has to be delivered and by whom. This is something that is really different from all other BIM standards internationally because this really gives you the exact information. That is the idea and also an advantage. The problem is that in the current stage of the development, you can neither get it into your software where something tells you this is the way you have to work and also there is a great issue that no one really understands where this information is set, because when you log into the property server, it is a mess until you find a wall and you know what to put where, and you need half an hour to understand what is happening.

- **How can the PS help with the implementation and usability of BIM?**

  The big question, when we are talking about BIM, is what is with the processes. How does this work, because no one is used to the object base working, so we usually work on documents and stack them on top of each other and everybody is fine. Now we have to go down to the object, down to the window, column, wall, and see what is happening there. And the Property server can help here, because we can make what is really needed, the attributes and parameters that have to be set, and determine by whom and in which stage. It really clears out how BIM is working. Of course, there are a lot of technical issues around it. When you have different software involved, it is a really big issue because how do you really define an attribute if you are not using the same model or the same software. However, I would say, that a significant help for the implementation is to have defined properties. And this can also accelerate the Open BIM workflows, because when you are down to the attribute level, you can work with databases instead of data formats, you can define them however you want, even in Excel, and the information can still be put into a model. So we are down on the information level and not on the model way, so this is quite helpful.

- **How is with the compatibility of the BIM programs (for example ArchiCAD, AllPlan,...)?**

  We didn't make anything new. We just took what was internationally defined. A wall is an IFC wall and it has some properties. In the IFC, this is called the property sets. And what we did was, we took those property sets and set them into a property server.

Every entry in the PS has a link directly to the BSD and IFC. So you can basically see what is this and it really helps to have things straight because then we have the international standards. The problem now is that every BIM offering software has a very different approach in handling the attributes and elements and so on. So, the idea was to do what is expected of the BIM software developers of the last 20 years but they never implemented. This is to make clean IFC exports, but through this, we hope that we can accelerate the process with them agreeing on the attributes they have to put in the software. Through making this an international standard, that is not yet in use, we can force the software developers to do this. Because when you have to deliver something like this, when you have to make a data drop, you have to be able to make clean IFC exports.

- **What is the ÖNORM 6241? What does it define? What were the challenges in the process of making the ÖNORM 6241?**

  The Önorm is in use or at least it was released in July 2015 and along with this, the Property server came by. Until now, there have only been a few projects that are referring to this standard. Why is this so? Because first of all, the PS is not understood by most of the people. Secondly, many functionalities are still lacking. Getting it into the software and out of the software has not been done yet, so people are rarely using it. But still, it is there and if you are a building owner you could say please deliver the data according to this standard. Nobody actually does this, because no one understands it, but you could use it already. However, we are only talking about the building elements (the lmp elements have not yet been implemented).

  It is a national standard; obviously, you have to deliver this if you agree on delivering this so yes, it is obligatory. However, for instance in other countries, you have the BIM standards that are used by the public hand. So if you consider BIG, a public owner of Austria, where they were developing this standard with other experts, but until now they have not asked for it yet, since they are not asking for BIM, they cannot ask for BIM according to the Önorm. As long as nobody is asking for BIM, no one will ask for a standard. And that is a big issue. There are also private building owners, like big industries, which already ask for BIM but are not aware of the Austrian standard and are therefore asking for some fuzzy British standard or something like this.

- **Are there any problems in the market because of the Önorm?**

  At the moment, the problem of the market in the German speaking area is is that there are basically no standards that you can use from project stage 0 to actually build the building. So we do not have any working standards, except of the Austrian BIM server, which has a following problem: When you take the Austrian standard, you can see that it is addressing the BIM Level 3. But this is not completely realistic because we do not even have any property set for the lmp elements. So, as you know, in Level 2, everyone has their things straight and in Level 3, we start working with integrated project deliveries. What the PS defines is a part of a building and a very few elements of this building. We can say it is an architectural Level 2. The only thing that is Level 3 inside of the standard is a table of who delivers what, to whom in a project and it is really ridiculous because it does not even describe the whole process.

  There are simply no rules where someone would tell you how to build up a model. In terms of attributes and elements, we started to do something with the PS, but there is no regulation about how do you really model the model, how do you work with a story's, split levels and so on, and therefore there is a really big mess when people start using it. Everyone is doing something, for instance Switzerland, Germany, Austria, but they are all slow and it is not really going anywhere. And the same issue is occurring here. We have a standard which is not really in use, but what we try to do is, we try to use the way over the European Standards Institute to get this idea going on for everyone to think about the internationally defined attributes, but until now, it has been a really big mess, because the big public owners already ask for it, but they do not have a standard, so they just take some Singaporean or British standard and say you should do things according to this standard.

  There are different classification standards. (the IFC, Uniclass, Omniclass, …) and you start over every time because all of those have totally different approaches. The problem arises whenever you are speaking with the building owners who are asking for BIM and say that they want different standards and as a planner, you are in a horrible position. Therefore, we are putting every possible standard there is into a library. So whenever you start building a model, you have all of the classifications already there.

- **How is the PS coordinated with the IFC? What is the connection between the PS, the ÖNORM 6241 and the IFC?**

  In the first stage, it was really a big mess, because it was all made by hand. You had to define the property and look into the BSD whether it is in there somewhere. The way it is meant to be is the following: you have a window width that is known across the world and it has a global identifier. For instance, when someone in China says that he needs a window width but he does not know the English word for it, he can define a new attribute which is called window width and this is the idea of the BSD as it is, but is not really working. Therefore, we checked for the PS: window width is it there somewhere and we need something to link it with. So we are working on the automatism that will do that for us.

  The connection between the PS, the Önorm and the IFS is for example window connection. We have a window and this one is defined in the BSD, IFC and AS, and it also has the properties which are also defined in those. And what we do in PS is we look into the AS and see which properties does the window have, we put those into the PS and then we just say from where something comes and who is in charge. This is really good because for example Germany can say that they need something in a different stage, someone else in charge, to add information, … we just change the numbers. And as a nation you just put a number and a person for each property.

- **What is the main difference between the ÖNORM 6241 and the IFC?**

  The IFC is just a classification system. You agree that this is a window and this is a window width. With the Önorm, we just add planning stages and authors to the IFC.

- **What is in your experiences the usage of BIM like in the companies? Is BIM better accepted among younger or older engineers? Do you think that BIM is more likely to be used in large companies?**

  I would say that every large company in the German speaking area has already picked up on using BIM. I would not say everyone is using it in large companies, but I think everyone is trying. So I think there are only very few companies that are still not working with it. The big issue is that in the German speaking area, 95 % of the market is represented by really tiny companies with 10 employees or less. And 90 % of companies

in Austria consist of two or less employees. Those guys are really afraid, because you need around 35,000–45,000 EUR to implement BIM (software, hardware, learn, …). That is why very a large share of the planning market is still not using BIM. First of all, no one is really asking for it, except really big owners who usually hire very big planners, but many offices are still not using it.

About the acceptance of BIM among younger and older engineers we can say that the acceptance and knowing about it is something different. We have a company here that has around 700 people and you can say it does not depend on the generation whether they accept BIM or not. We have people who are 25 years old and are not even close to that much acceptance than people who are 60 years old. It depends on the acceptance. Of course, you have people who are working in a certain way for 30 years and when someone tells them we will be working in a totally different way from now on, it is an issue. What we experienced is that it is not a matter of generation. Of course, we picked up in the last years that people who are coming from the universities are starting to get to know BIM and we actually have people who are coming from the university and are used to working with BIM. Those would never accept drawing lines again. Once you have done this, you would not go back. But we also have a lot of people leaving the TU and not knowing what BIM is about.

- **Do you think that there is a significant connection between how digitalization is anchored in the company and how well BIM is known?**

  Digitalization is a big word in the planning industry. Some may say, we are using the CAD, we are digitalized and have digital workflows. The big thing is object oriented thinking. That is like the great issue that we call digitalization. BIM is in one way equal to digitalization and on the other hand, the AutoCAD is also a digital project. The main thing is whether to accept ready-made objects to create our projects. I think especially architects are still not really too much into it. Because every object, such as a column for example, is a program inside of a program and what you have to do is use a catalogue of things to assemble a building. And that definitely limits you in the sense of creativity and free forms. So I think that it is about whether you accept working in this manner, to use the ready-made objects and intelligent things that are as intelligent as the program made them and not as intelligent as me as a planner would make them or not. Of course

you can also create your own objects, but no one teaches you that. And it depends on the software how hard this is.

- **Is it likely that the costs are lower in the companies who are using BIM than in those that did not anchor the digitalization and BIM?**

  Let us put it this way. It really depends on which level you are working on. So I think that if you are a small office and you concentrate on working in Level 2 BIM for your own purposes, I would bet that you are more productive and you have a return of the investment very, very fast. Because I implemented BIM into many companies and they are still very pleased and they say they have doubled the speed of workflows, the whole thing is made fast and easy. I think it gets complicated in large companies because you have a lot of people and everyone is changing something and you have to make things work for everyone and you always have to teach them, make sure that everyone is working on the same standard. This is not an issue in small companies because everyone is sitting next to each other and you just ask them: ok, how do you do this? In large companies, on the other hand, you have to guarantee that everyone is working on the same standard and this is a really a big issue. So, in Level 2, you can get in a very short amount of time a lot more productive than when you were drawing lines, and you probably will end up having more productive workflows and higher earnings. That is what I experienced in small companies. When it comes to Level 3 and the interdisciplinary processes, large companies, larger projects, I would say it really depends on how well people are educated, how complicated your standards are. I think that at the end, for these companies it will turn out that they are more productive when they have good users, but the issue is having good users and the question is how much time and money you have to spend to make those people to really do what you want them to do. Also a serious issue for us is knowledge management. The software is changing all the time, workflows are changing, and once you implemented something and have presented it to everyone, while the next day it is over and you have to teach people something all over again and tell them this is how we will do it from now on. That is what makes you more effective and efficient, but it is a very big issue how will you spread this all over the company.

- **What is in your experience the average BIM level of companies?**

At the moment it is Level 1. Everyone is basically using the 3D models and the CAD. There are studies claiming that in the German speaking area, around 30 % of the market is using the BIM capable software, to which level it is unknown, but usually these are very basic workflows. Let us say that somewhere between 15 and 20 % of the people are using it, but again, that is mostly in large companies and large projects. I doubt that in small companies and small houses anyone is using it. But on the other hand, I know many architecture studios working in Level 3 and not knowing this, because they are using software like Revit, Archicad or something else and do not know the word BIM. It is really funny actually, people are coming to me saying I would like to work with BIM and then you come to their office and you see that they have been working with Archicad from the start and they really have perfect BIM Level 2 models, but they just simply do not know that. In the German speaking area, there are many people working with those tools, but most of them are not aware of the profits they can get out of them and what they really are. Especially on Level 3, there are only a few large companies.

- **What could be done to improve knowledge, awareness … about BIM?**

  The BIMpedia. At the moment, all companies are working on the same problem. We have to solve technical issues, the process problems, we have to establish how to make models that work in a certain way. The problem now is that large companies are doing it, but they are doing it all by themselves. Since we have no real research on it and no real working standards, everyone has to do it. And we have started 5 years ago. We needed modelling standards, the standards of what information is put in which object, and we had to create the workflow processes. And after a couple of years, we figured out that this is what the market needs. Therefore, we created a very extensive knowledge platform containing all this knowledge. It took 50,000 hours of development and creation of standards and we put it into an online documentation system and made this accessible to the whole market. Even to all small companies who could never afford it. We went online on 1 April this year. The basic idea is that we have just made a description for all the disciplines of a model: how do you really model this, what properties do you have to define, what planning stage you are on and how things work along with simulation and so on. We also included tutorials how to do this in different software. I think this is what the market need at the moment. We need the inexpensive knowledge available for everyone to really get things going because no small company

could afford to build up something like that. And we asked ourselves, how do we usually learn? You go to a training, you pay a lot of money for a 5-day course and after two weeks you forget everything and it is over. Therefore, we took the price of a usual training day (500 EUR) and we spilt it by two and this is the price for accessing the BIMpedia for one year.

The basics you have to know while using BIM: storey, multilayers walls … We also have articles, issues, how to do something. We go through every element that is present in the building. Every article contains the planning stages, the information about what is the level of detail, what are the attributes that are needed to be defined according to the standard and how can you do this in Archicad, Revit … It is also always updating with the novelties and updates of the standards.

We have the modelling guidelines that give you a basic knowledge and also the theory of BIM. You can decide which software you will use, what do you want to learn depending on your profession and so on. Currently, the platform is only in German, but we are planning to make it in English as well. We are also planning to include other standards and the National annexes. We offer courses as well.

11.7 Expert Interview E4: CEO, Software solutions company

- **What are CAFM Software and CAFM Systems? How are CAFM Systems implemented into the IT landscape?**

CAFM = Computer-Aided Facility Management. It is a support for the facility management processes with software. Most companies already have software for production, human resources, etc. A huge task is to implement the CAFM system in the existing landscape. An important component is the production of interfaces, for example: SAP, Navision, Microsoft Dynamics, Lotus Notes or other document management systems.

- **What is pit- (pit-FM, pit-mobile)?**

Pit is a brand, and the company is called pit-cup GmbH from Heidelberg (Germany). The product pit-FM is the main product. The second product is pit-cup software for

building technology (CAD). Pit-FM (CAFM), the facility management software, is also possible as an Internet solution (pit-WEB) or as an App for smartphones and tablets for iOS and Android.

- **What are the advantages and disadvantages of pit - and how is pit- accepted among the experts? Who can use your software?**

The advantages are also the disadvantages of pit-FM. Pit-FM is very flexible to the needs of different customers and industries. Thus, the application area is very large and complex. The number of modules, as we call these functional areas, because they are all represented in one model, is over 100. The examples include area management, maintenance, vehicle fleet management, disposal management, work safety, hazardous material management, etc. The disadvantage of this is that hardly any customer wants to use the standard application, but rather a solution adapted for him. As a result, the implementation takes longer than for the standard software. Customers are as diverse as the solutions in pit-FM. Some of them are hospitals, automotive suppliers, banks, cities and municipalities, universities, the Republic of Austria through the Federal Real Estate, housing associations, industry in many industries.

- **How can pit- help with the implementation and usability of BIM?**

The roots of the pit-software and the philosophy of the concept is that it is a computer program to support a continuous process and flow of data for planning and building. That was our concept 25 years ago. Today it is called BIM.

The technologies are now improved and modern. With pit-FM we can connect Revit natively and via a configurable interface bidirectionally visualize all desired data exchange. If CAD models are available in IFC, we can also use them via IFC Revit-Pit-FM.

- **In which countries can pit- be used and in which countries is it already used?**

Pit-FM is speech-neutral programmed. Depending on the user, the corresponding language is displayed. Thus, pit-FM can be used worldwide. Our customers use pit-FM

throughout Europe, USA, Canada and China.

- **How is with the compatibility with the BIM programs (for e.ArchiCAD, AllPlan ...)?**

The roots of the pit-software and the philosophy of the concept is that it is a computer program to support a continuous process and flow of data for planning and building. That was our concept 25 years ago. Today it is called BIM. The technologies are now improved and modern. With pit-FM we can connect Revit natively and via a configurable interface bidirectional all desired data exchange and of course also in Revit visualize. If CAD models are available in IFC, we can also use them via IFC Revit-Pit-FM.

- **Who can participate in the courses at your academy? What is the main purpose of those courses?**

Anyone interested in the pit--products or FM and building technology information can register with us for training courses and seminars. It is mainly for the program users and administrators of our customers. The benefit is to get to know the applications and to use them efficiently in their own workspace.

- **How is pit- coordinated with the ISO standards?**

Pit- is a German product. Thus, the main focus is on the DIN standards and the VDI and VDMA standards. A large part of the DIN standards has already been translated into the ISO standards and vice versa. Here, we have the advantage that Germany is a great player in Europe.

- **For which countries is it already usable? How is with the implementation of the ISO of other countries (National Annexes)?**

In principle, you can use the program worldwide, see also the answer to question 1.e. Since pit-FM is an open system, you can import catalogues and records from country-

specific regulations.

- **What do you think are the most appropriate metrics to measure BIM implementation, maturity and readiness?**

  The native connection to AutoCAD and Revit and the use of web service technology to dock the existing IT world are key criteria. The replacement of countless Excel lists and the resulting data consistency and data security are large acceptance drivers.

- **What is from your experiences the usage of BIM like in the companies? Is BIM better accepted among younger or older engineers? Do you think that BIM is more likely to be used in large companies?**

  I think that age does not play a crucial role. Of course, the "digital natives" do more easily with the modern media, but the computer and CAD are already relatively old. BIM finds its use from top to bottom. This means that large companies have of course the greatest benefit and also large projects which bring the highest benefit. However, we now notice the trend that even small companies are dealing with BIM in order not to miss the „train“.

- **Do you think that there is a significant connection between how digitalization is anchored in the company and how well BIM is known?**

  I can only answer yes. We get a lot of inquiries in the sense of "you can come to us and show us BIM". That means they do not even know what BIM is or that it is a process or a technology and we only provide tools with the software.

- **Is it likely that costs are reduced in the companies who are using BIM as opposed to those that did not anchor the digitalization (meaning BIM)?**

  The initial investment is certainly higher and the employees also have to be trained on the new technologies. The first projects will cost more as the processes are new or at least different. The owner of a property has reduced the cost of the building's life cycle from the outset. However, the goal should be a long-term cost saving in all trades.

- **What is from your experience the average BIM level of companies?**

  In the architecture sector, close to 80% for large companies such as ATP, in engineering and plant construction max. 50%. The operators of facilities I still appreciate in Europe are at the very beginning of BIM.

- **What should still be done to improve the usage of BIM in companies and projects?**

  BIM has to get a step deeper into the education from the universities and research areas. In the technical schools and technical colleges. There is still a lack of well-trained experts for BIM. The guidelines of the policy to approve public building projects only with BIM go in the right direction.

- **What are your goals for the future regarding BIM?**

  Our goal is to be one of the leading players for the BIM tools. With our products for architecture, building technology and facility management, we are well positioned here.

11.8 Questionnaire

1 Standardseite

Dobrodošli v vprašalniku:

"Digitalni barometer – industrija grajenega okolja v digitalni transformaciji"

Cenjeni strokovnjaki,

Veseli nas, da ste se odločili sodelovati v naši anketi!

V zahvalo vam bomo ob zaključku te ankete poslali brezplačen povzetek najpomembnejših rezultatov. Podrobnosti so na voljo na koncu ankete.

Anonimnost je zagotovljena, prav tako iz odgovorov na anketna vprašanja ni možno pridobiti vaših osebnih podatkov in podatkov o vašem podjetju. Vaše sodelovanje je za nas zelo pomembno in prav tako vaš dragocen čas, ki ga boste posvetili reševanju te ankete.

S spoštovanjem,

Amanda Jus, Fakulteta za gradbeništvo, prometno inženirstvo in arhitekturo, Univerza v Mariboru, Gradbeništvo BMAG, Gradbene konstrukcije

Prof. Dr. Andrej Tibau, Katedra za gradbeno in prometno informatiko, Fakulteta za gradbeništvo, prometno inženirstvo in arhitekturo, Univerza v Mariboru

Prof. Dr. Iva Kovačić

Industriebau und interdisziplinäre Bauplanung, Forschungsgruppe Integrale Planung, TU Wien

Prof. Dr. Markus Schmidiger

Institut für Finanzdienstleistungen Zug, Competence Center Immobilienmanagement, Hochschule Luzern

2 Standardseite

Na katerem področju je Vaše podjetje najbolj aktivno?

Arhitektura.

Biro.

Glavni izvajalec.

Nadzor / Upravljanje objektov.

Marketing.

Investitor.

Gradbeno podjetje / Dobavitelj.

Gradbeni izvajalci.

Javni sektor.

Drugo.

Je vaše podjetje mednarodno aktivno?

Da. Ne.

Kje je vaše podjetje registrirano?

Slovenija.

Avstrija.

Nemčija.

Švica.

Drugo (navedite):

3.1 Standardseite

Koliko zaposlenih za polni delovni čas zaposluje vaše podjetje na mednarodnih projektih?

<10

10–49

50–249

250–1000

>1000

Nič.

4 Standardseite

Koliko zaposlenih za polni delovni čas zaposluje vaše podjetje v Sloveniji?

<10

10–49

50–249

250–1000

>1000

Kakšna je vaša vloga v podjetju?

Arhitekt.

Inženir.

Manager.

Direktor / Ponudnik storitev.

Tržnik / Prodajalec.

Investitor / Lastnik.

Najemnik / Uporabnik.

Svetovalec.

Drugo.

Kakšna je vaša funkcija v podjetju?

Zaposlen brez nadzorne funkcije.

Zaposlen z nadzorno funkcijo.

Območni vodja.

Upravitelj.

Lastnik.

Koliko ste stari?

< 26
26–35
36–45
46–55
56–65
> 65

5 Standardseite

Ali je digitalizacija zasidrana v poslovnih načrtih?

Da. Ne. Ne vem.

Kako ste zadovoljni s trenutnim stanjem digitalnih rešitev vašega podjetja na delovnem mestu?

Zelo zadovoljen. Precej zadovoljen. Precej nezadovoljen. Nezadovoljen.

Ali vaše podjetje ponuja zaposlenim možnosti notranjega ali zunanjega izobraževanja o digitalizaciji?

Da. Ne. Ne vem.

6 Standardseite

Na katerih področjih so se do sedaj v vašem podjetju zgodile največje spremembe zaradi digitalizacije?

Prosimo, da izberete največ tri področja.

Razmerje s strankami.

Notranji procesi.

Poslovni modeli.

Ponudba izdelkov in storitev.

Odnosi z dobavitelji.

Drugo (navedite):

Na katerih področjih se bodo v naslednjih treh letih v vašem podjetju izvedle največje spremembe zaradi digitalizacije?

Prosimo izberite največ tri področja.

Odnosi s strankami.

Notranji procesi.

Poslovni modeli.

Ponudba izdelkov in storitev.

Odnosi z dobavitelji.

Drugo (navedite):

7 Standardseite

Kako vidite svoje podjetje danes v zvezi z digitalnimi instrumenti v industriji?

Inovatorji.

Med prvimi.

Zgodnja večina.

Pozna večina.

Zaostajanje.

Kako vidite svoje podjetje v treh letih v zvezi z digitalnimi instrumenti v industriji?

Inovatorji.

Med prvimi.

Zgodnja večina.

Pozna večina.

Zaostajanje.

Ali vaše podjetje sistematično analizira podatke za izpeljavo strateških odločitev (Big data)?

Da. Ne. Ne vem.

8 Kundenverhalten

V kolikšni meri se strinjate z naslednjimi trditvami o vedenju kupcev v okviru digitalizacije?

	Da, vsekakor	Da, verjetno	Verjetno ne	Vsekakor ne	Ne vem
Stranke izvajajo več primerjav in so zato bolj osveščene o ponudbi konkurence.					
Stranke so v splošnem pričele dajati velik poudarek ceni.					
Zvestoba strank se je zmanjšala.					

9 Kundenverhalten 2

Katere od naslednjih zahtev stranke zahtevajo od vašega podjetja?

Stranke...

Popolnoma drži	Drži	Ne drži	Popolnoma ne drži	Ne vem

želijo spletno komunikacijo.

želijo sodelovati preko socialnih omrežij in sodelovati pri obliki.

želijo navodila / spletno strokovno pomoč.

zahtevajo "digitalne prototipe" (3D-Model, Video-Simulacija, itn.).

zahtevajo večji odzivni čas.

10 Kundenverhalten 3

Kakšen delež strank je seznanjenih z vašim podjetjem preko spletnih portalov?

0–20%

20–40%

40–60%

60–80%

80–100%

Ne vem.

Koliko strank dostopa do vaše spletne strani mobilno (preko telefonov, tabličnih računalnikov)?

0–20%

20–40%

40–60%

60–80%

80–100%

Ne vem.

Koliko strank je bilo seznanjenih z vašim podjetjem pred prvim stikom?

0–20%

20–40%

40–60%

60–80%

80–100%

Ne vem.

11 Kundenverhalten 4

Kako ocenjujete naslednje trditve v zvezi s kontaktom s strankami?

	Se strinjam	Se ne strinjam	Ne vem
Zaradi digitalnih orodij boljše poznamo potrebe strank.			
Kontakt s strankami je zaradi digitalnih orodij postal anonimen.			

12 Ersatzprodukt

Kakšen delež vaših storitev lahko potencialni kupec sam pridobi na internetu?

0–20 %

20–40%

40–60%

60–80%

80–100% Ne vem

Kakšen delež vaših storitev bo potencialnemu kupcu v treh letih dostopen preko spleta?

0–20 %

20–40%

40–60%

60–80%

80–100%

Ne vem.

13 Lieferantenmacht

Kako se je vaše sodelovanje z dobavitelji spremenilo zaradi digitalizacije? Sodelovanje je...

	Se strinjam	Se ne strinjam	Ne vem
Hitrejše.			
Manj pomanjkljivo.			
Cenejše.			
Nasploh bolj učinkovito.			

14 Lieferantenmacht 2

Kot posledica digitalizacije je dobavitelja težje zamenjati.

Se popolnoma strinjam.

Se dokaj strinjam.

Se bolj ne strinjam.

Se sploh ne strinjam.

Ne vem.

V kolikšni meri je izbira dobavitelja odvisna od uporabljenih digitalnih sistemov?

Zelo.

Precej.

Malo.

Sploh ne.

Ne vem.

15 Markteintritt

Digitalizacija je manjšim podjetjem omogočila lažji prodor na trg. To velja predvsem za:

	Da, vsekakor	Verjetno da	Verjetno ne	Vsekakor ne	Ne vem
Start-up podjetja Tuja podjetja.					
Podjetja iz drugih sektorjev.					
Dobavitelje, ki prav tako ponujajo naše storitve.					

16 Markteintritt 2

Kateri dejavniki mislite, da pomagajo drugim ponudnikom storitev pri vstopu na trg?

	Zelo	Delno	Ne tako zelo	Ne vem
Lažji dostop do digitalnih platform.				
Boljše informacije o trgu zaradi digitalizacije.				
Manjši stroški zaradi obsega ekonomije.				
Internacionalizacija lastnih poslovnih modelov.				

17 Wettbewerb

Zaradi ozadja digitalizacije se je konkurenca v industriji spremenila:

	Se strinjam	Se ne strinjam	Ne vem
Cenovna konkurenca je postala močnejša z digitalizacijo razpoložljivih podatkov.			
Kvaliteta konkurence je postala močnejša.			

Marže so se zmanjšale.
Pomen osebnih odnosov se je zmanjšal.
Dobičkonosnost se je zmanjšala.

Zaradi ozadja digitalizacije smo pridobili ali izgubili tržni delež.

Pridobili.

Izgubili.

Ostalo enako.

Ne vem.

18 Kommunikationskanäle

Kateri nov segment strank ste do danes lahko pridobili na račun digitalizacije?

	Da	Ne	Ne vem
Nove regije.			
Nove ciljne skupine.			
Nove industrije.			

Katere nove segmente strank boste lahko pridobili v naslednjih treh letih na račun digitalizacije?

	Da	Ne	Ne vem
Nove regije.			
Nove ciljne skupine.			
Nove industrije.			

19 Kommunikationskanäle 2.1

Katere digitalne komunikacijske kanale pogosto uporabljate za komunikacijo s strankami?

	Dnevno	Tedensko	Mesečno	Redkeje	Ne uporabljamo
Internetna stran.					
Novice.					
E-mail.					
YouTube.					
Xing.					

LinkedIn.
Google+.
Twitter.
Facebook.
Blog.
Platforma zaščitena z geslom.
Lastne aplikacije.

Katere digitalne komunikacijske kanale boste pogosto uporabljali v treh letih za komunikacijo s strankami?

	Bolj pogosto kot danes	Manj pogosto kot danes	Ostalo enako
Internetna stran.			
Novice.			
E-mail.			
YouTube.			
Xing.			
LinkedIn.			
Google+.			
Twitter.			
Facebook.			
Blog.			
Platforma zaščitena z geslom.			
Lastna aplikacija.			

20 Kommunikationskanäle 3.1

Katere klasične komunikacijske kanale pogosto uporabljate za komunikacijo s strankami?

	Dnevno	Tedensko	Mesečno	Redko	Ne uporabljamo
Osebno svetovanje.					

Pisno.

Javni dogodki.

Industrijski dogodek / sejem / konferenca.

Obisk / Showroom.

Katere klasične komunikacijske kanale boste v treh letih uporabljali za komunikacijo s strankami?

	Več kot danes	Manj kot danes	Enako
Osebno svetovanje.			
Pisno.			
Javni dogodki.			
Industrijski dogodek / sejem / konferenca.			
Obisk / Showroom.			

21 Kundenbeziehung

Naši zaposleni v prodaji morajo danes predvsem:

Skleniti prodajo.

Graditi odnose.

Svetovati s strokovnim znanjem.

Drugo (navedite):

Naši zaposleni v prodaji bodo morali v treh letih predvsem:

Skleniti prodajo.

Graditi odnose.

Svetovati s strokovnim znanjem.

Drugo (navedite):

22 Wertschöpfung

Katere vrednote lahko danes ponudite strankam zaradi digitalizacije?

	Popolnoma drži	Drži	Ne drži	Popolnoma ne drži	Ne vem
Večja hitrost.					
Večja kvaliteta.					
Večja individualnost.					
Nižja cena.					

Katere vrednote boste lahko v treh letih ponudili strankam zaradi digitalizacije?

	Popolnoma drži	Drži	Ne drži	Popolnoma ne drži	Ne vem
Večja hitrost.					
Večja kvaliteta.					
Večja individualnost.					
Nižja cena.					

23 Digitale Instrumente

Katere od naslednjih digitalnih instrumentov uporabljate pri delovnem procesu?

Možnih več odgovorov.

- CAD.
- BIM (Building Information Modeling).
- 3D-Modeliranje.
- Simulacije.

CRM-programska oprema.

Internetni nepremičninski portali.

Spletne podatkovne sobe za projektno delo.

Software za vodenje gradbenih projektov.

CAFM-Software.

Sistemi za upravljanje stavb.

GIS-Info.

Spletna zemljiška knjiga.

Video Tour.

3D-Render.

Virtualna resničnost.

Droni.

3D-Tiskanje.

Software za upravljanje.

Sistem za upravljanje Portfolio.

Pregledna orodja.

24 Key Resources

Kateri so ključni dejavniki uspeha pri povečanju digitalizacije?

Možnih več odgovorov.

Ustvarjanje dolgoročnega odnosa s strankami.

Dober spletni dostop do izdelkov in storitev.

Vitek proizvodni proces.

Digitalni Know-How.

Hitrost.

Katera področja v vašem podjetju so se do danes zaradi digitalizacije najbolj spremenila?

	Zelo	Delno	Zelo malo	Se niso spremenila	Ne vem
Odnos z dobaviteljem.					
Produkcija / pridobivanje naročil.					
Prodaja / odnosi s strankami.					

Katera področja v vašem podjetju se bodo zaradi digitalizacije v naslednjih treh letih najbolj spremenila?

	Zelo	Delno	Zelo malo	Se niso spremenila	Ne vem
Odnos z dobavitelji.					
Produkcija / pridobitev naročil.					
Prodaja / odnosi s strankami.					

25 Key Resources 2

Kakšne so vaše zahteve za prihodnje digitalne sisteme, ki bi vaše poslovanje naredile boljše?

Lažja uporaba / uporabnost sistemov.

Boljše povezovanje in boljši vmesniki sistemov ter baz podatkov.

Digitalizacija / avtomatizacija preprostega rutinskega dela za poenostavitev vsakodnevnih operacij (npr. arhiv, elektronski podpis).

Uvedba in izvajanje posebnega novega sistema, in sicer (navedite):

Ne vem.

26 Mitarbeiter

Kako je digitalizacija vplivala na vedenje zaposlenih?

Popolnoma drži	Drži	Ne drži	Popolnoma ne drži	Ne vem

Digitalna pismenost zaposlenih je v skladu z zahtevami digitalnega dela.

Naši zaposleni so večinoma odprti za nove digitalne rešitve.

Rekrutiramo lahko zadovoljivo kvalificirane delavce.

27 Mitarbeiter 2.1

Število zaposlenih se je zaradi digitalizacije spremenilo v primerjavi s prodajo:

Vnesite spremembe glede na trenutno stanje.

	Povečalo	Zmanjšalo	Ostalo enako	Ne vem
V akviziciji.				
V proizvodnji.				
V prodaji.				
V administraciji.				

Število zaposlenih se bo v naslednjih treh letih zaradi digitalizacije spremenilo v primerjavi s prodajo:

Vnesite spremembe za naslednja tri leta.

	Povečalo	Zmanjšalo	Ostalo enako	Ne vem
V akviziciji.				
V proizvodnji.				
V prodaji.				
V administraciji.				

28 Einnahmen

Kakšen vpliv ima digitalizacija na prihodke v vašem podjetju?

Prihodki na stranko so se s povečanjem digitalizacije:

Povečali.

Zmanjšali.

Ostali enaki.

Ne vem.

Prihodki individualnega dela so se zaradi digitalizacije:

Zvišali.

Zmanjšali.

Ostali enaki.

Ne vem.

Digitalizacija je ustvarila nov prihodek:

Da.

Ne.

Ostalo enako.

Ne vem.

29 Kosten

Kakšen vpliv ima digitalizacija na stroške v vašem podjetju?

	Da	Ne	Ostane enako	Ne vem
Stroški pridobivanja naročil se večajo z večanjem digitalizacije.				
Stroški proizvodnje se večajo z večanjem digitalizacije.				
Stroški prodaje se zmanjšujejo z večanjem digitalizacije.				
Stroški administracije se večajo z večanjem digitalizacije.				

30 Kosten 2

Kakšen vpliv ima digitalizacija na stroške v vašem podjetju?

Skupni stroški so:

Manjši Večji Ostali enaki Ne vem

Skupni stroški oglaševanja so:

Manjši Večji Ostali enaki Ne vem

31 Planung 0

Ali je vaše podjetje vključeno v načrtovanje in/ali gradnjo nepremičnin?

Da Ne

32.1 Planung

Ali ste v vašem podjetju v zadnjih dveh letih v načrtovanje in gradnjo vpeljali nove metode?

Da.

Ne.

Imamo namen v prihodnosti.

Ne vem.

32.1.1.1 Planung 2

Kakšni so bili razlogi, da ste v vašem podjetju vpeljali nove metode v načrtovanje in gradnjo?

Možnih več odgovorov.

Zmanjšanje stroškov.

Povečanje hitrosti.

Poenostavitev notranjih procesov.

Izboljšanje povezave z dobavitelji / kupci / udeleženci projekta.

Ponudba novih izdelkov / storitev.

Predlagano je bilo s strani strank.

Zamenjava zastarelega sistema.

Drugo (navedite):

Ne vem.

32.1.1.2 Planung 3

Ali ste z uvedbo novih metod dosegli pravkar omenjene cilje?

(V primeru, da ste na prejšnje vprašanje odgovorili z "ne vem", na to vprašanje ne morete odgovoriti.)

	Smo dosegli	Nismo dosegli	Ne vem
Zmanjšanje stroškov Povečanje hitrost.i			
Poenostavitev notranjih procesov.			
Boljša povezava z dobavitelji / strankami / udeleženci projekta.			
Ponudba novih izdelkov / storitev.			
Je bilo predlagano s strani strank.			
Zamenjava zastaranega sistema.			
Drugo (Prej navedeno).			

32.2 Planung 4

S kako velikimi projekti se v glavem ukvarjate v vašem podjetju?

do 500.000 EUR.
do 2.500.000 EUR.
do 10.000.000 EUR.
do 25.000.000 EUR.
nad 25.000.000 EUR.
Ne vem.

32.3 Planung 5

Kakšno metodo načrtovanja uporabljate v vašem podjetju?

	Vedno	Pogosto	Redko	Ne uporabljamo	Načrtujemo v prihodnosti
Načrtovanje z uporabo 2D-načrtov (analogno / digitalno).					
Načrtovanje z uporabo 3D-Modelov (samo geometrija: dolžina, širina, višina).					
Načrtovanje, ki temelji na komponentno usmerjenih gradbenih modelih (BIM).					
4D - BIM: Integracija informacij procesa (dodan čas in časovni potek projekta).					
5D - BIM: Integracija informacij procesa (dodani stroški, količine, viri).					
6D - BIM: Integracija dodatnih informacij procesa (analiza življenjskega cikla (npr. upravljanje z objektom, vprašanje trajnosti)).					
Drugo.					

32.4 Planungskoordination 1

Kako uravnate različne vsebine in statuse projekta s projektnimi partnerji?

	Vedno	Pogosto	Redko	Ne uporabljamo	Ne vem
Prilagoditev natisnjenih načrtov.					
Iz 2D datotek (npr. dxf, dwg).					
Iz 3D datotek (npr. 3dm).					
Z uporabo digitalnega modela stavbe.					
S preverbo modelov zgradbe z Model.					
Checker.					
Bilanca, ki temelji na modelnem strežniku.					

32.5 BIM 1

Kako dobro poznate BIM (Building Information Modeling) metodologije načrtovanja?

Slišal za to.

Seznanjen/a sem z BIM, vendar ga ne uporabljam.

Pred kratkim smo uvedli BIM (pred manj kot 1 letom).

BIM uporabljam že nekaj časa (več kot 1 leto).

Ne poznam.

32.6.1 BIM 2

Zakaj BIM načrtovanja v vašem podjetju ne uporabljate?

Možnih več odgovorov.

Uporabljene metode so zadovoljive za potrebe naših projektov.

Stroški nakupa programske opreme in usposabljanja delavcev so preveliki.

Ker ne izvršujemo projektov s kompleksno geometrijo, nimamo potrebe po uporabi BIM modelov.

Pristop, ki je komponentno orientiran omejuje svobodo načrtovanja. Uporabljamo Plug-ins za parametrično načrtovanje.

Nihče ne zahteva uporabe BIM.

Pomanjkanje ustrezno usposobljenih strokovnjakov.

Težave s kompatibilnostjo različnih programov.

BIM nameravamo vpeljati v prihodnosti.

Drugo (navedite):

Ne vem.

32.7.1 BIM 3

Kaj razumete pod pojmom BIM (Building Information Modeling)?

Možnih več odgovorov.

Je predvsem programska oprema.

Je predvsem način dela / mišljenja.

3D render projektov.

Strukturirano povezovanje geometrije in informacij gradbenih del.

Digitalni model za skupno delo.

Ne vem.

Ali v okviru BIM-a vidite kakšno dodatno vrednost ali celo nove poslovne modele za vaše podjetje?

Da.

Ne.

Mogoče.

Ne vem.

Kdo mislite, da ima največjo prednost pri uporabi BIM-a?

Možnih več odgovorov.

Gradbinec.

Arhitekt.

Projektant.

Gradbeno podjetje.

Proizvajalec komponent.

Upravljalec objekta.

Storitve nepremičnin.

Investitor.

Drugo (navedite):

Ne vem.

32.7.2.1 BIM 4

Kakšen delež vaših projektov, s katerimi se ukvarjate danes, upravljate z BIM modeli?

0–20% 20–40% 40–60% 60–80% 80–100% Ne vem

Kakšen delež projektov, s katerimi se boste ukvarjali v naslednjih treh letih, boste upravljali z BIM modeli?

0–20% 20–40% 40–60% 60%–80% 80%–100% Ne vem

32.7.2.2 BIM 5.1 heute

V kakšni meri uporabljate prej našteta orodja BIM v fazah, opredeljenih z HIA (Honorarinformation Architektur)?

Prosim navedite pogostost uporabe v tem trenutku.

	Vedno	Pogosto	Redko	Ne uporabljamo
1. Faza: Strateško načrtovanje.				
2. Faza: Predhodna študija / načrtovanje.				
3. Faza: Načrtovanje / Osnutek.				
4. Faza: Razpis / Izvajanje načrtovanja.				
5. Faza: Javna naročila / izvajanja.				
6. Faza: Upravljanje.				

Kako intenzivno boste v naslednjih treh letih uporabljali prej omenjena BIM orodja v fazah opredeljenih v HIA (Honoara Information Arhitektur)?

Prosimo navedite uporabo za naslednja tri leta.

	Vedno	Pogosto	Redko	Ne uporabljamo
1. Faza: Strateško načrtovanje.				
2. Faza: Predhodna študija / načrtovanje.				
3. Faza: Načrtovanje / osnutek.				
4. Faza: Razpis / načrtovanje izvajanja.				

5. Faza: Javna naročila / izvajanje.

6. Faza: Upravljanje.

32.7.2.2.1 BIM 5.14

Če uporabljate metodo načrtovanja BIM: Kako vaše podjetje sodeluje s projektantskimi partnerji?

	Vedno	Pogosto	Redko	Ne uporabljamo	Ne vem
Na skupnem digitalnem modelu preko spletnega strežnika.					
Na več digitalnih modelih načrtovanja v obliki modulov in hierarhij.					
Vsak projektant dela na svojem modelu, kjer se lahko izvozijo ali uvozijo spremembe.					
Vsak projektant dela na svojem modelu, spremembe morajo biti vnesene ročno.					
Projektni partnerji ne uporabljajo tega pristopa.					
Drugo.					

32.7.3.1 Planungskoordination 2

Pri delu z digitalnimi modeli objektov je sodelovanje in organizacija projekta:

	Se strinjam	Se ne strinjam	Ne vem
Hitrejše, dodatni detajli niso več potrebni Cenejše zaradi večje učinkovitosti.			
Lažje.			
Manj napak Bolje načrtovano.			
Bolj transparentno (boljša komunikacija pri načrtovanju in gradnji).			
Bolj kreativno (večje možnosti oblikovanja).			

Na splošno boljše kakovosti.
Druge.

32.7.4.1 Planungs- und Bauprozess 1

Za proizvodnjo- / proizvodne procese: Kako vaše podjetje pridobi podatke za načrtovanje od partnerjev za izvedbo in proizvodnjo komponent?

	Vedno	Pogosto	Redko	Nikoli	Ne vem
Direkten uvoz.					
2D- / 3D-podatki kot osnova in lastni modeli.					
2D-podatki.					
Ustrezen berljiv format za proizvodni stroj Pretvorba formata za proizvodni stroj. Prenos lastnih formatov stroja Programiranje za prenos podatkov Digitalizirani analogni načrti.					
Analogni načrti so za proizvodnjo dovolj.					

32.7.4.1.1 Planungs- und Bauprozess 2

Katera izjava, navezujoč na knjižnico komponent, velja za vaše podjetje?

	Drži	Ne drži	Ne vem
Imamo svojo lastno knjižnico komponent.			
Uporabljamo predvsem knjižnice proizvajalcev / dobaviteljev.			
Uporabljamo predvsem BIM platforme (BIMobject, idr.).			

32.7.5 Planungs- und Bauprozess 3

Ali bi morala poklicna združenja poenostaviti uporabo BIM-a z inštrukcijami, primeri dobre prakse, pogodbene dokumente idr.?

Da, to bi bilo v pomoč.

Ne, na voljo je že dovolj regulative, najbolje, da trg to regulira sam.

Ne vem.

32.7.6 Planungs- und Bauprozesse 4

Ali bi moralo biti za obdelavo BIM-a več honorarja?

Da, to so dodatni stroški v primerjavi s klasičnimi metodami.

Odvisno od projekta.

To ne bi bilo možno pri večjih gradbincih.

Ne, BIM že veliko doprinese z izboljšano komunikacijo.

Ne vem.

32.7.7 Planungs- und Bauprozesse 5

Ali upoštevate pravila, ki jih predpisuje BIM za uporabo posamezne metode?

Da, vedno.

V kolikor je to zahtevano od nas zaradi kompleksnosti projekta.

To bomo zahtevali v prihodnosti.

Ne, tega ne načrtujemo.

32.7.8 Planungs- und Bauprozesse 7

Kako ocenjujete pomen oblikovanja podatkov v obliki BIM modela za vaše delo?

Nepomembno.

Brez BIM bi bilo naše delo dražje, kar bi bilo slabše za stranke.

Podatki projektantov za naše aktivnosti niso pomembni.

32.7.9 BIM - Businessperspektive 3

Po mojem mnenju BIM pomaga:

Se strinjam	Se ne strinjam	Ne vem

Zmanjšati stroške.

Poveča prihodke.

Poveča donose projektov.

Zmanjša tveganja projektov.

33 **Standardseite**

Zahvaljujemo se Vam za Vaše sodelovanje. Poslali Vam bomo brezplačen povzetek glavnih rezultatov ter naslednje popuste za konferenco in študijo o nepremičninskem sektorju.

Kot je navedeno zgoraj, dobili boste 20% popust na kotizacijo za konferenco Nepremičninski sektor v digitalni dobi, ki znaša 450,00 EUR in bo potekala v četrtek, 8.6.2017. Če se konference ne boste mogli udeležiti, lahko naročite izvod spremne študije po posebni ceni 64,00 EUR (redna cena 80,00 EUR).

Želim naročiti brezplačen povzetek glavnih rezultatov in kupon za 20% popust na kotizacijo za konferenco Nepremičninski sektor v digitalni dobi na svoj e-mail naslov.

34 **Standardseite**

Lanska študija **"Digitalni barometer - nepremičninska industrija v digitalnem preoblikovanju"** obravnava vprašanja o spremembah v vedenju kupcev, vplivu na modele in vplivu digitalnega preoblikovanja na trženje in prodajo anketiranih. Ponujamo vam elektronsko verzijo v pdf. formatu po ceni 10,00 EUR, ter v kolikor ste zainteresirani za tiskano verzijo, jo lahko naročite po posebni ceni 40,00 EUR (redna cena 80,00 EUR),

V žarišču:

Kako se bo spremenil trg in poslovni modeli?

- Kateri ključni trendi oblikujejo industrijo nepremičnin?
- Kateri dogodki vplivajo na trg in poslovne modele podsektorjev?
- Kako se morajo organizacije prilagoditi, da bi bile uspešne?

Kako se spremeni trženje in prodaja?

- Kako deluje trženje in prodaja v digitalni dobi?
- Kako se lahko orodja socialnih omrežij uspešno uporabljajo?
- Kako virtualna resničnost spreminja pričakovanja kupcev?

Kateri proizvodi in storitve bodo uspešni?

- Kaj ločuje stanovanja od digitalnih domačinov?
- Kaj pomeni novo delovno okolje za poslovne stavbe?
- Kako deljena ekonomija spreminja industrijo nepremičnin?

Naročite **Študijo (mehka vezava)** na vaš naslov:

Ime / Priimek

Podjetje:

Ulica in hišna številka:

Pošta:

Mesto:

Država:

35 Danksagung

Hvala za Vaše sodelovanje! S svojim mnenjem ste pomembno prispevali k anketi.

Lep pozdrav,

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