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INNOPOLIS Engineering

Background document of developing the vision of e-construction platform

2018

Contents

INTRODUCTION

With the leadership of the Ministry of Economic Affairs and Communications, the goal has been set to raise the productivity of the construction sector to the average level of the European Union by 2030 the latest. Respective estimated growth would be threefold. Prerequisite of increasing productivity involves elevating the added value of construction per employee of the sector. This is achievable via development of technology (including digitalization, standardization, automation, robotization) and management (including digital data exchange, managerial capability, collaborative capacity, transparency, quality-based contracts). Majority of the afore-mentioned items refer to the need of digitalization and application of e-solutions.

Considering the objective of increasing the added value of the construction sector and facilitating the way to the added value for the market participants, the Ministry of Economic Affairs and Communications set the aim on **developing the vision of e-construction platform**, which would cover the complete life-cycle of a building from planning till demolition, and in the future would be the basis of IT architecture and detailed functional description that are necessary for enforcing the vision. **E-construction solutions should ensure uniformity and transparency of planning, designing, constructing and utilizing buildings, with simultaneous reduction of the costs of financial and human resources throughout the life-cycle of the building.**

This background document of e-construction vision forms one part of the vision of e-construction platform. The goal of the background document is to give an overview of the current status of the construction industry and the trends that influence the sector. The background document describes the starting point and presumptions underlying the compilation of the vision of e-construction platform.

The background document contains a review of the current status of the construction industry in Estonia, including the best practices and existing hindrances. It also explains the general trends of the construction industry and e-construction, and contains respective success stories. The document provides the description of most important stakeholders and their wishes and needs that are relevant from the viewpoint of realization of the vision. In addition, the document discusses most significant strategic documents and legal acts concerning the field.

The following constitutes the basis of compilation of the background document:

- interviews conducted with various parties of the building's life-cycle (in total, 16 interviews were done from 24.07.2018 till 07.09.2018);
- field-specific surveys and guidance materials compiled on the order of the Ministry of Economic Affairs and Communications;
- field-specific laws, legal acts, standards and guidance materials;
- value stream mapping analysis of the building's life-cycle prepared by the digital construction cluster;
- international professional literature and results of conducted studies;
- other relevant materials.

Vision of e-construction platform and the accompanying background document has been compiled by Civitta Eesti AS on the order of the Ministry of Economic Affairs and Communications over the time period from June 2018 till November 2018.

1. GENERAL TRENDS OF THE CONSTRUCTION INDUSTRY AND E-CONSTRUCTION

1.1. OVERVIEW OF THE CONSTRUCTION SECTOR

The construction sector is extremely influential industry in Estonia and across the world. The effect on the economy is direct and accounts globally for approximately 13% of the world's gross domestic product[1], but also indirect by creating the built environment that surrounds us. High-grade built environment is particularly important in the context of Estonia, as we spend approximately 90% of our lives indoors. Energy consumption is significantly higher than European average because of the northern climate, and amounts to 50% of the energy balance of the whole country. The number of companies and activities that are associated with the construction sector is extremely large, starting from extraction of mineral resources and manufacturing of building materials, and ending with property management and cleaning services. **Global volume of the construction sector is around 8.6 trillion euros that is predicted to raise to 12 trillion euros by 2025[1].** Volume of European construction sector was 1.03 trillion euros in 2016. Volume of the sector is predicted to be 1.26 trillion euros by 2021, which in comparison with 2016 means growth of 21.9%[2].

Construction sector of **the European Union** is characterized by cyclical development. Downturn of the construction sector that followed the last economic crisis lasted until 2014. **Subsequent growth has been moderate (3.9% in 2017), and in consequence the sector accounts for approximately 8.9% of the gross domestic product in the European Union[3].** Growth of the sector is prognosed also for the succeeding years, but in a smaller extent than before (approximately 2% a year).

One reason of the positive trend of the construction sector expansion of the last years has been the economic growth that has increased the income of households, companies and the public sector. In addition, positive influence derives from low interests, migrant crisis, urbanization and reduction of public sector investments during the economic crisis and after it. [4]Despite the upward trend, the proportion of the construction sector in total economy is still significantly lower than its weight before the economic crisis.

Although the construction sector forms a very important part of total economy, its productivity is substantially lower than other sectors. Macroeconomic study on the productivity of the construction sector in the United States of America reveals that the productivity index of the manufacturing industry has raised over 150% over the last 50 years. **Productivity of the construction sector has decreased 19% during the same time period[5].** Considering the gross weight that the construction sector has in economy, even a relatively small increase in productivity and added value would have a significant impact on economy as a whole. One of the most important factors of raising the productivity of the sector lies in digitalization of processes which results in substantial reduction of resource costs of activities. Pursuant to the analysis of the Boston Consulting Group, **the construction sector will be fully digitalized by 2025**, which in respect to nonresidential buildings would enable to **save globally 0.6 to 1 trillion euros per year in construction and engineering, and 0.25 to 0.4 trillion euros per year in operations**[6].

The construction sector has significant economic impact also in Estonia – in 2017 there were 57,000 employees in the construction sector (section F of the Estonian Classification of Economic Activities (EMTAK) of 2008), which formed 8.7% of all workers[7]. This is supplemented by employees of neighboring specialties. In comparison with 2016, construction volume of Estonian construction market increased in

[1] McKinsey Global Institute. Reinventing Construction: a route to higher productivity. 2017
[2] MarketLine Industry Profile. Construction in Europe. 2017
[3] FIEC. Annual Report. 2018
[4] https://www.kof.ethz.ch/en/news-and-events/media/press-releases/2017/11/european-construction-industry-is- ooming.html; http://www.ebc-construction.eu/index.php?id=3; http://euroconstruct.org/ec/press/pr2018_85
[5] World Economic Forum. Shaping the Future of Construction. 2016
[6] The Boston Consulting Group. Digital in Engineering and Construction. 2016
[7] Statistics Estonia. TT0200: Employed persons by economic activity (EMTAK 2008)

2017 by 23%[8]. **On the same year, the construction sector accounted for 8.4% of Estonian gross domestic product[9].** Despite comparatively large employment rate and total volume, the construction sector faces problems with productivity of the workforce – hourly productivity of the construction sector formed in 2016 only 71% of the average of all industries[10].

1.2. DIGITALIZATION IN THE CONSTRUCTION SECTOR

Various business sectors have made capital of information and communications technology (ICT) revolution, and raised their throughput significantly with process and product innovation. At the same time, the construction sector has shown incapability of following the technological revolution and sector's workforce productivity has stagnated. Standstill has various internal and external reasons, including for example massive vertical and horizontal fragmentation of the sector, limited knowledge transfer between projects, tight competition and the resultant low margins.

Global overview of the construction sector prepared by KPMG in 2017 revealed that although the world's leading construction companies have made significant investments into solutions and methods of project, risk and value management, productivity has not increased over time, and there are still substantial problems with timely completion of projects and adherence to the budget. The construction sector lacks integral approach to administration, and management of human resources, projects and technology is not integrated.

55% of the subjects interviewed in the survey found that the sector is ready for radical changes (disruption). Out of the companies that participated, 72% have set their strategic goals on innovation, technology and data, but only 48% of the companies have developed an activity plan for application of ICT technology. Digitalization and utilization of integrated project management information system are regarded as the main value.

Major hindrance to improving data exchange is considered to lie in the substantial vertical and horizontal fragmentation of the sector. Data and processes are therefore also scattered between very different systems. Hence, companies do not get the benefit of their investment in more efficient data management, as other participants of the sector are not willing to come along with the innovation[11].

According to the joint manifesto of the European Construction Industry, digitalization is the main solution for staying in competition, and thereat digitalization needs to happen across the whole value chain. Digitalization should not be a goal on its own, but a device for achieving strategic objectives, such as increased productivity, circular economy principles and a better living environment[12].

Due to the obstacles described above, the public sector plays the critical guiding and coordinating role in digitalization of the construction sector. The public sector is able to create the necessary data exchange standards and platforms, and to enact regulations and standards with the goal of harmonizing data exchange principles and making data accessible and processable. In addition, the public sector is capable of initiating and leading the discussion of digitalization in the society.

1.3. DEVELOPMENT TRENDS

The origins of (r)evolutionary changes driving to increased productivity in the construction sector involve application of ICT solutions, automation, introduction of novel management techniques and sustainable development of the built environment.

[8]Statistics Estonia. Press release of 2018. Ehitusmaht mullu suurenes
[9] Statistics Estonia. RAA0043: Output, intermediate consumption and value added by economic activity (EMTAK 2008)
[10] Statistics Estonia. EM008: Enterprises' value added and productivity measures by economic activity (EMTAK 2008) and number of persons employed
[11] KPMG International. Global Construction Survey: Make it, or break it. 2017
[12] The European Construction Industry Manifesto for Digitalisation. 2018

AUTOMATION

Automation of operational processes via robotic and ICT solutions has taken extensively place in various business sectors, but has not gained a footing in the construction sector. There are several technological solutions under development in the domain that could significantly improve project management and automate processes, but their application has been slow. Over 75% of the companies that participated in the survey of KPMG have not employed automation in their enterprises and believe that the construction sector requires more than five years for it to be a widespread practice. However, there are various innovative developments in the sector[13]:

AUTOMATION OF PROCESSES	• Machine-controlled automated construction vehicles that utilize 3D ground models and GPS input information are being used in road construction. • In the field of building construction, welding robots and automatized bricklayers are being developed in the world. • Automated designing is used for simpler objects.
USE OF DRONES AND 3D SCANNING	• Using drones in combination with 3D scanning and building information modelling (BIM) enables to monitor the formation of an object operatively. • 3D scanning enables to monitor the progress of construction and simplifies project management. • 3D scanning of existing buildings enables to prepare the information model for compiling renovation documentation or for building management.
UTILIZATION OF 3D PRINTERS	• There are first functional prototypes in the world that are capable of printing buildings on the basis of the model.
DATA-DRIVEN PROCESSES, BIG DATA, MACHINE LEARNING	• It is possible to find more optimum solutions than before for analyzing massive volumes of data which results in improved quality of decisions. For example, comparison of data collected with building automation enables to detected potential causes of inefficacy and opportunities for saving.
FACTORY-PRODUCED ELEMENTS	• Construction involves elements that are manufactured at the controlled conditions of a factory and are assembled at the building site. In Estonia, this is widespread in manufacturing of concrete elements and wooden structures.

CONSTRUCTION ADMINISTRATION AND INFORMATION MANAGEMENT

Professional literature and various international strategy papers reveal that building information modelling (BIM) is the main solution for improving data management and exchange of information in the construction sector.

BIM (*BUILDING INFORMATION MODEL, MODELLING, MANAGEMENT*)

[13] http://eprints.tktk.ee/1171/1/loputooKristoNomm.pdf

The objective of building information modelling is to create a coordinated system and processes for the management of the building's life-cycle. Information models contain building design data on the physical, functional and other characteristics of the building. BIM technology increases transparency, facilitates exchange of construction information between the project's partners (i.e., between the contracting entity and the contractor), and enables to reduce mistakes, waste of resources and delayed deadlines of projects, which ensures efficacy of construction works and maintenance[14]. **Use of BIM also entails direct economic benefit: on the basis of various studies, BIM enables to save up to 40% on incidental expenses and waste, and according to different sources 5–20% on construction costs[15].**

In addition to direct utilization of technology during the construction process, various frameworks of construction process management have been developed, and these can significantly improve the processes and reduce the costs deriving from inefficacy. Thereat, BIM also has remarkable synergy with many of the other development trends. BIM simplifies collaboration between different parties, which is the presumption of utilizing integrated project delivery (IPD) method. Information model contains data in machine-readable harmonized format, which is necessary for automation of operational processes. Information model enables to obtain a more complete view of the building and to use various simulations that are the requisite for evaluating energy efficiency.

LEAN CONSTRUCTION

This project management methodology derives from industry, and its goal is administration and constant improvement of construction process, by reducing the proportion of waste over various stages of constructing. Lean construction is not grounded on the classical construction management principle pursuant to which the total is the sum of summands, but it handles construction process as a whole. This requires combining the resources of the company: employees, technology and business processes. Lean construction has not spread quickly in the construction sector, because it presumes alternating the culture and processes of the whole organization and presupposes giving up on the habitual and well established project-centered approach.

INTEGRATED PROJECT DELIVERY

IPD is a project management method in case of which contracting is based on one agreement between the main partners, which ensures that parties to the contract are bound to the project as early as possible, and guarantees solidary liability for risks. Common contracting method of construction process has created a situation where each process party (architect, designer, builder, contracting entity) is interested in maximizing the profit only in their own stage. In doing so, they do not pay attention to constructing the building in the best possible way. Utilization of IPD is not very widespread in Estonia, because applying the contracting methods of IPD implies that the contracting entity has much more cognizant approach and leads the project on a larger scope. Also, contracting entities are insufficiently aware of success stories on the obtainable benefit, which has enforced the myth that utilization of IPD increases the costs of completing a project[16].

Framework of IPD is similar to alliance contracting method, which is also based on the relationship between the project's partners. Alliance contracts have been used in many successful projects performed in Finland. For example, the first pilot project in 2015 was completed three months before the term in virtue of using the alliance method.

INNOVATION IN BUILDINGS

In addition to innovation in processes and technology, it also occurs in buildings.

NEARLY ZERO-ENERGY REQUIREMENT

One of the major challenges of Estonian construction sector for the coming years is the requirement concerning nearly zero-energy buildings. Pursuant to the directive of the European Commission on the energy performance of buildings, all new buildings must fulfill the requirement of nearly zero-energy from 2020. One of the biggest fears of constructing nearly zero-energy buildings is disproportionately massive increase of construction price, but the survey of TalTech conducted in 2017 reveals that constructing nearly zero-energy buildings is cost-optimal across their life-cycle (saving on heating costs

[14] Tallinna Tehnikaülikool. Ehitusinfo modelleerimise regulatsiooni süsteemi alusuuring II. 2016
[15] Puust, R. Mis takistab meil BIMist kasu lõikamast. 2016
[16] Tallinna Tehnikaülikool. Integreeritud projektiteostuse (IPT) korraldusmudeli kasutamisest ehitushanke juhtimisel. Juhendmaterjal. 2016

over 30 years compensates the larger initial investment)[17].

Constructing nearly zero-energy buildings requires developing the awareness and skills of contracting entities, planners, designers, consultants and all other construction process participants. Merely from the standpoint of construction physics, construction of nearly zero-energy buildings and their relevant renovation demands more responsible work than has been performed in accordance with previous practice. Achievement of energy efficiency goals in a building with low energy costs depends on the building's structures and utility systems. Utilization of BIM supports the construction of nearly zero-energy buildings, because such complex approach to a building presumes a more comprehensive overview already in the designing phase.

Precise constructing infers to skillful planning and options for detailed surveillance and quality control throughout the construction process and later exploitation of the building. Fulfillment of these conditions inevitably requires extensive implementation of ICT solutions, and BIM applications in particular[18].

In addition to direct energy efficiency of a building, more attention is being paid to sustainable construction across the whole life-cycle. Moreover, consideration is given to the environmental impact of production and post-demolition recovery and utilization of building materials. Reduction of the environmental impact of buildings requires a more cognizant and integrated approach to planning and designing buildings. Resorting to digital solutions like BIM enables to plan all construction-related factors in more detail and to decrease waste during construction.

SMART CITIES AND HOUSES

In addition to energy efficiency, another spreading trend involves so-called smart houses and city districts, where a lot of attention is paid to solutions concerning the Internet of things, building automation and remote management. Effective application and mutual integration of such solutions requires thoughtful planning. For example, integration of smart solutions enables to control lighting, heating, ventilation, multimedia, locks and the security system in an integral way. It is also possible to analyze the collected data and to identify options for optimization. Important origins of a smart city include automation and optimization (energy recovery, street lighting, public transport, parking, data management) as well as data-driven planning and administration.

Building automation solutions (particularly heating, ventilation, security and fire safety systems) are common in constructed nonresidential buildings, such as office buildings and public buildings. However, inadequacy is observable in complete integration, which would be necessary for taking the efficacy of management to the next level. Smart house solutions are not yet so widespread in residential buildings. First smart city pilot projects in Estonia have been undertaken in the city center of Tartu[19] and Ülemiste City business park.

Combining smart house solutions with building information model allows to optimize management costs and to use (semi-)automatic diagnostics.

1.4. EXISTING INITIATIVES FOR DEVELOPING THE CONSTRUCTION SECTOR

INITIATIVES OF THE EUROPEAN UNION

On the European level, the construction sector is heading towards digitalization. Utilization of BIM across the building's life-cycle is considered to be one of the main keys to increasing productivity. **From the viewpoint of preparing the Estonian vision of e-construction platform, it is necessary to pay attention to the initiatives of the European Union and the Member States for various reasons:**

- In order to avoid even larger backwardness in productivity, consideration must also be bestowed upon the development of the Estonian sector and productivity upgrade on the national level. Delayed reaction could infer to decreased competitiveness and marginalization.
- Initiatives of other countries enable to transpose best practices and to go by their recommendations.
- We should use widespread operational processes and technological solutions (e.g., classification

[17] Tallinna Tehnikaülikool. Hoonete kuluoptimaalsete energiatõhususe miinimumtasemete analüüs. 2017
[18] Eesti Arengufond. Nutika spetsialiseerumise kasvualade raport. 2014
[19] http://tarktartu.ee/

systems, file formats) in order to stay in international competition.

Majority of European countries are developing digital construction process on the national level[20]; activities of Great Britain and Finland in the field of digitalization of the construction sector are described in more detail in chapter 3. In order to avoid decline in cost-effectiveness of the construction sector that might derive from differences in strategies taken within the European Union, it is vital that public procurers would collaborate inside the economic zone and enable digitalization of the construction sector, raise in efficacy and better export opportunities for small and medium-sized enterprises in particular[21]. One example of the European Commission's initiatives has been **establishment of the *EU BIM Task Group* – a working group of public procurers and policy makers, which is also actively attended by the Ministry of Economic Affairs and Communication**. The goal of the working group is to harmonize the approach of different countries towards introducing BIM, and to create a common trans-European base that could be used as guidance. The working group has conduced the compilation of *EU BIM Handbook* that contains BIM implementation principles for public procurers.

BIM AND LIFE-CYCLE INITIATIVES IN ESTONIA

Various initiatives for integrating BIM have been commenced in Estonia on the level of the public sector. These initiatives have provided first experiences and success stories on utilization of BIM, and agreed common development trends which to pursue.

BIM working group of public procurers

With the leadership of the Ministry of Economic Affairs and Communications, declaration of mutual intentions on application of building digital information model of public procurers and policy makers of the Estonian property sector (BIM working group of public procurers) was signed in July 2017. As of today, the declaration has been signed by State Real Estate Ltd (Riigi Kinnisvara AS; RKAS), RB Rail AS, Port of Tallinn Ltd (AS Tallinna Sadam), Tallinn City Council (Tallinna Linnavalitsus), the Estonian Road Administration (Maanteeamet), and the Ministry of Economic Affairs and Communications, and various other institutions. **The objective of the declaration is to introduce among public procurers the utilization of building information modelling across all stages of building's life-cycle.** This is achieved by sharing the knowledge and best practices with the contracting entities, conducting joint pilot projects and establishing working groups in order to reach a mutual approach. This also involves preparation of an activity plan and a timetable for implementation of BIM, and collaboration with research organizations and educational institutions[22].

State Real Estate Ltd and Estonian Road Administration as pioneers

State Real Estate Ltd and Estonian Road Administration as public procurers with significant market power have commenced various initiatives for implementation of BIM across the building's life-cycle.

State Real Estate Ltd started with introduction of BIM already in 2008. As of today, State Real Estate Ltd requires the use of BIM in designing, construction and maintenance. Also, State Real Estate Ltd has initiated the compilation and translation of various field-specific guidance materials. State Real Estate Ltd disclosed in April 2018 the updated requirements on nonresidential buildings, which form the basis of their procurements, and part 1 stipulates the requirements on utilizing BIM.

Estonian Road Administration requests on design procurements the submission of 3D model of the covering layer. Today's main problem is the inadequacy of the requirements that apply to the information model, and the models are therefore frequently functionally unusable for construction companies. The intention is to improve the requirements applicable to the information model gradually in liaison with various parties. At the time of preparing the vision, two BIM pilot projects were commenced in cooperation with the private sector. In one project, common data environment between the parties (contracting entity, designer, builder) was used for administration of the design and construction process. In the second project, cloud-based project bank is being used for managing the works at the construction stage. Estonian Road Administration has commenced the development of road life-cycle information system (tee elukaare infosüsteem; TEIS) in order to improve information

[20] https://www.thenbs.com/knowledge/working-towards-a-unified-approach-to-BIMin-europe
[21] http://www.rkas.ee/bim/eu-bim-tooruhm
[22] https://www.mkm.ee/sites/default/files/avaliku_sektori_tellijate_uhiste_kavatsust_1.pdf

management. This system aggregates the data on the whole life-cycle of roads that are managed by Estonian Road Administration. Information system is being developed as modules within the scope of a three-year project.

Digital construction cluster

One important initiatives involves the creation of digital construction cluster. Partners that participate in the cluster include innovative enterprises of the sector, institutions of higher education and centers of competence. **The digital construction cluster aims to shift paradigms inside the construction sector with information and communication technologies, while placing significant emphasis on altering business customs and models.** Additional goal is to create a construction environment, where collaboration between various parties is valued highly and the building is monitored throughout the life-cycle – from idea inception to utilization.

The cluster is focused on developing knowledge-based construction, where the general goal of the construction sector is increased added value, which is technically also described as resource reduction per production unit. Main innovations include novel collaboration structures used for designing, construction and maintenance, software and digitalization of construction documentation, and therefore facilitation of paperless operation between all parties (including also local governments and state agencies that issue permits).

Creation of the cluster allows to deal with an important hindrance of the construction sector – it enables innovative enterprises to have meaningful cooperation with other parties of the building's life-cycle and to share experiences on implementation of innovations.

1.5. FACTORS THAT IMPEDE THE DEVELOPMENT OF CONSTRUCTION IN ESTONIA

Despite the development opportunities described above, there are several factors which encumber the development of the construction sector. **Significant cyclicality of the construction market does not motivate the companies to make long-term development plans.** More than 95% of the sector's companies are microenterprises that lack the resources for implementing systemic innovations. Major fragmentation results in the risk that the innovation initiated by one enterprise fails when other companies of the sector do not come along with it.

Another significant hindrance lies in the lack of employees with professional education. **Pursuant to the survey of 2014, only 41.5% of the employees of construction companies are vocationally educated.** This indicator places Estonia to the last position in Europe[23]. The number of people entering degree courses of construction-related specialties has reduced by one fourth over the last five years. It is estimated that the insufficiency of people graduating from engineering field will amount to approximately one third over the coming years. The labor market is lacking practically oriented engineers who could work as project or object managers. Utility systems are becoming more complex, which results in particular lack of engineers of heating, ventilation and cooling, water supply and sewerage. The number of people graduating from construction-related specialties is not sufficient for covering the need of new highly-skilled employees[24]. This could be one of the reasons behind the slow implementation of digital solutions.

Digitalization presumes implementing large-scale changes in the construction sector. It requires alteration of internal organizational processes and principles of collaborating with other parties. Gaining trans-sectoral benefit from digital solutions requires modification of paradigms and business models across the sector. The construction sector is considered to be a traditional economic sector with low innovation readiness that generally is not prone to implement changes quickly and efficiently. The analysis conducted by Margus Sarmet in 2014 on the order of the Ministry of Economic Affairs and Communications identified **7 main factors that impede innovation in Estonian construction sector**:

- Estonian **construction object (and its contractual volume) is** commonly so **small** that it does not provide motives for applying innovative methods on designing and building.

[23] Eesti Konjunktuuriinstituut. Eesti ehitusfirmade tööjõualane olukord ja perspektiivne tööjõu vajadus. 2014
[24] SA Kutsekoda. Tulevikuvaade tööjõu- ja oskuste vajadusele: ehitus. 2017

- **Engineering technicians** working in the construction sector **are not prepared** to elaborate innovative solutions.
- **Contracting entities of buildings and their potential consultants do not favor utilization of innovative solutions** on the construction object under order, and require typical and well-tested solutions. Thereat the foremost factor hindering innovation lies in low technical competency of the contracting entities and their consultants, incomplete or incompetent initial briefs, risk aversion and insufficient skills of innovation management, rather than conceptual conservatism.
- **Contracting methods** (including forms of contracts) that are used in the construction sector **do not support innovative approaches taken by the designer and the builder**. However, this factor does not impede innovation directly, and Estonian legal system enables to agree on anything.
- Economic depression results in **very short periods covered by contracts** for the construction sector participants, and undertakings do therefore not have business interests for investing into further future and engaging in development.
- **Tight time schedule** for designing, preparing construction works and building **impedes evolving, testing and implementing innovative solutions**.
- **Procurements in the construction sector** (both public and private procurements) are mainly **based on the criterion of the lowest price**, and hence contractors do not have the funds for conducting or financing costly research and development activities that would lead to innovation.

2. CURRENT SITUATION IN ESTONIA

2.1. MAIN OBSTRUCTIONS OF BUILDING'S LIFE-CYCLE

The center of e-construction conception and digitalization of constructing lies on the information created during the building's life-cycle[25], and its management and exchange between different parties. **Preparation of the vision of e-construction platform is mainly based on the problems and respective solutions identified during interviews conducted with field-specific experts.**

Estonian construction sector companies mainly utilize narrow project-based approach. This is done within the scope of a single project, where attention is paid only to one's participation in the process and the view of the complete life-cycle is ignored, and also from the standpoint of the company's development, where main emphasis is placed on completing each project as efficiently as possible and potential long-term gains (e.g., benefits of integrating BIM) are neglected. This has also been promoted by the decisions of the contracting entity (searching the most remunerative solution at each stage) and the contracting methods used.

One important problem is the organization and culture of work that is wide-spread in the construction sector and involves concealment of mistakes, and conscious and occasionally malevolent expedience of mistakes that have occurred in other stages with the intention of maximizing one's own benefit. Undertakings that follow this business model are not interested in open information exchange and transparency.

Main concerns of the **organization of work** between the parties of building's life-cycle are the following:

- Performer of the next stage is often engaged in the process too late. For example, earlier involvement of the builder in the designing process would reduce alterations of the construction project during building. Substantive cooperation of various parties of the building's life-cycle would enable to find the best possible solutions.
- Information exchange between the parties and feedbacking are insufficient. For example, builders or administrators do not give the designers feedback on the purposefulness of the utilized solutions.
- Work is frequently performed in an environment with incomplete information, which results in significant uncertainty and risks.
- Constant alterations to the initial brief that the contracting entity makes at a later phase of designing suppress the whole process to a remarkable extent and cause additional costs. Another problem lies in the fact that the contracting entities often delay decision-making when it is necessary to choose the most suitable solution.
- Various control mechanisms do not serve their purpose. For example, expert assessment or owner's supervision of a building design frequently focuses on formal defects, and does not involve substantive analysis.

Mentioned concerns result in significantly increased timely demands for all parties as well as quality-related problems. Subsequently, this infers to remarkable additional expenses for the contracting entity in the preparation, building and operation stages.

Major inefficacy also derives from problems related to information exchange and management. Main issues that concern information exchange are mapped in the following table by life-cycle stages and activities. Data provided in the table originates from the interviews conducted with participants of the construction sector.

[25] In the context of this document, building's life-cycle is defined as a conception that characterizes the stages of buildings, from initial idea until demolition. Building's life-cycle stages are specified in standard EVS (ISO) 29481, and they are also described in guidance material, IDM guide (2010) prepared by BuildingSMART. Building's life-cycle stages include the stage preceding the life-cycle (planning, concept), pre-construction stage (designing), building, operation (maintenance) and demolition.

ACTIVITY	INPUT INFORMATION (SOURCE OF INPUT INFORMATION)	FACTORS CHARACTERISTIC TO INPUT INFORMATION	OUTPUT	CREATOR OF THE OUTPUT
Stage preceding the building's life-cycle (planning, concept) This stage involves inception of the idea of constructing the building, establishing the preliminary presumptions, conducting the cost-benefit assessment, and compilation of the initial brief for designing. In case of public procurers, this stage also includes the design contest which results in creation of the architectural draft.				
Analysis of the business plan, cost-benefit assessment (and design contest)	Market information (internal information of the developer, information obtained from public databases)	Very heterogeneous material, all developers have their own indicators that they analyze.	Initial brief for designing, architectural draft	Contracting entity (architect, planner)
	Comprehensive and detailed spatial plans, design specifications (local government)	Mainly provided in a non-processable format (.pdf), which causes the risk of making mistakes on re-nomination. The city of Tallinn has a register of the spatial plans of Tallinn. The Estonian Land Board has a map of detailed spatial plans, but all local governments do not use it; only the plans established over the last years are available. Common database of comprehensive and detailed spatial plans has not been created, and therefore the necessary data has to be obtained from the local government on certain occasions.		
	Previous research – environmental studies, geodetic surveys, etc	Studies are stored in various databases and are frequently not available to unauthorized persons. There is no overview of which surveys already exist.		
	Map of restrictions (the Estonian Land Board)	Does not contain all necessary information. There is no certainty that the presented information is relevant.		
	Special requirements of state agencies (Estonian Rescue Board, National Heritage Board, the Environmental Board, etc)	Mainly available only as text.		
Finding and acquiring the suitable plot	Detailed information of the registered immovable (land register)		Contract of purchase and sale of the plot	Developer, notary
Pre-construction stage (designing) This stage involves compilation of the construction project, application for building permit, arrangement of the construction procurement and conclusion of the construction contract.				

ACTIVITY	INPUT INFORMATION (SOURCE OF INPUT INFORMATION)	FACTORS CHARACTERISTIC TO INPUT INFORMATION	OUTPUT	CREATOR OF THE OUTPUT
Designing	Initial brief of the contracting entity (contracting entity)	The level is very uneven, there is no common form for preparing the initial brief. Initial brief depends on the contracting entity's awareness and collaboration with the designer/architect. The contracting entity is frequently incapable of evaluating the value that making a bigger contribution at this stage would have for the next phases.	The building design (preliminary, principal or operational building design documentation), information about the building and the plot, solutions for separate parts (including layout plan, architecture, structural part, heating, ventilation, water supply, electrical installations, fire safety), plan for service and maintenance	Architects, engineers
	Architectural draft (architect)	Usually submitted in .dwg or .pdf format; depends on the architect's customs and requirements of the contracting entity. Occasionally an information model is also prepared.		
	Spatial plans and design specifications (local government)	Refer to the description under the previous stage.		
	Special requirements of state agencies (state agencies)	Refer to the description under the previous stage.		
	Studies (geological, geodetic, environmental impact)	Studies are scattered, there is no uniform overview of what has been done before, surveys are occasionally unobtainable.		
	Requirements deriving from laws, regulations and standards (State Gazette, Estonian Centre for Standardisation)	Textual documents; standards of Estonian Centre for Standardisation are fee-charging.		
	Precepts of utility network operators (technical conditions)	On each instance it is necessary to consult with the network operators. Information is textual and occasionally does not comply with real terms.		
Application for energy label	Building design documentation (designer)	Even if building design documentation is provided in the form of a information model, it is not compatible with the software used for energy label calculations, and a new model is prepared each time.	Issued energy label	Specialist of energy efficiency / energy auditor
Application for building permit	Building design documentation (designer)	Takes place via the register of construction works (EHR), but its utilization is complicated. Many entries are made manually. The risk of making mistakes is high.	Coordination	Neighbors, state agencies, utility network operators

ACTIVITY	INPUT INFORMATION (SOURCE OF INPUT INFORMATION)	FACTORS CHARACTERISTIC TO INPUT INFORMATION	OUTPUT	CREATOR OF THE OUTPUT
			Building permit	Local government
Author's supervision	Building design documentation (designer)	The architect intervenes often too late and making alterations is costly.	Conformity control	Architect
Expert assessment of building design documentation	Building design documentation (designer)	The expert does not provide substantial verification, but examines compliance with the law and optimizes his/her volume of work. Expert assessment is ordered only when it is obligatory under the law.	Expert assessment report	Expert
Budgeting of the construction cost	Building design documentation (designer)	When the building design documentation is provided on 2D drawings, construction volumes are calculated manually; it would be possible to calculate the volumes automatically from the information model. Calculations are often inaccurate, variability is extensive and works are divided between various budget lines. There is no uniform classification.	Price calculation	Designer
Building This stage involves building – from preparations for building work until transfer of the building. A lot of building information is created during construction. The goal of construction documents is to ensure transparency and traceability of building, which enables to assess the quality and conformity of constructing.				
(Preparation of operational building design documentation)	Principal building design documentation (designer)	Design documentation is compiled in .dwg + .pdf or information model format. Main contractor does not place confidence in the principal building design documentation, and wishes to use habitual solutions and to optimize the costs. Principal building design documentation contains substantial mistakes. Design documentation of separate parts is incompatible. There are also significant errors concerning assembly logics.	Operational building design documentation	Main contractor/ designer
Construction commencement notice	Building permit (local government)	Proceedings are slow. The official delays the process, by asking questions periodically. Questions/remarks are controversial. The official does not take responsibility. Only formal verification is performed. Approvals are given with delays, deadlines are extended. Obtaining an approval presumes a building design documentation of a very high level of detail (utility network operators).		

ACTIVITY	INPUT INFORMATION (SOURCE OF INPUT INFORMATION)	FACTORS CHARACTERISTIC TO INPUT INFORMATION	OUTPUT	CREATOR OF THE OUTPUT
Construction process management	Operational building design documentation, drawings (main contractor)	All mistakes are not corrected on making alterations. Operational building design documentation is prepared in a hurry, it is often compiled in parallel with construction works and on the account of the time indicated for building.	Journal of building operations, as-built drawings, reports of covered work, instruments of receipt and delivery, videos and photographs illustrating the process, minutes of construction meetings, instructions on use and maintenance, surveying records	
Building		When alterations are made during construction, the updated drawings may not reach the sub-contractor on time or they might remain disregarded.		
Owner's supervision	Building design documentation, all created documents (main contractor)	Owner's supervision does not entail enough liability. Work is optimized. The goal is not the construction of the building, but getting one's work done.	Conformity control	
Author's supervision		Refer to the description under the previous stage.	Conformity control	Architect
Application for use and occupancy permit	Documentation created during construction (main contractor)	Takes place via the register of construction works (EHR). The requirements on the documents to be submitted are occasionally extremely detailed, the official is overwhelmed with information in order to avoid potential additional questions.	Use and occupancy permit	Local government
Operation (maintenance) The goal of immovable property administration and maintenance is to have constant overview, which ensures physical, legal and economical preservation of the property by administering the processes related to property utilization. It is important to emphasize that the total length of the stage preceding the life-cycle, the designing stage and the building stage is ten times shorter than the building's operation stage, which makes the maintenance stage crucial from the aspect of life-cycle costs (expenses of the operation stage form 70% of life-cycle costs according to a Finnish survey)[26].				
Management	Building design documentation, building certificate, instructions on use and maintenance, initial brief of the contracting entity (builder/contracting entity)	The builder overwhelms the administrator/contracting entity with information, and therefore it is difficult to orientate in the surplus of information. It is necessary to categorize and filtrate the information. Change of the owner/administrator results in major information loss.	Maintenance strategy, maintenance plan, economic plan, management plan, procurement documents, contracts, instruments of delivery and receipt, accounting documents	Administrator

[26] Tallinna Tehnikaülikool. Ehitusinfo modelleerimise regulatsiooni süsteemi alusuuring II. 2016

ACTIVITY	INPUT INFORMATION (SOURCE OF INPUT INFORMATION)	FACTORS CHARACTERISTIC TO INPUT INFORMATION	OUTPUT	CREATOR OF THE OUTPUT
Service and maintenance	Maintenance instructions and maintenance schedule of used materials and equipment (administrator/ contracting entity)	Information is dispersed in various databases. Maintenance schedule is usually provided as a textual document.	Maintenance journal, reports of performed work	Provider of maintenance services
Preparation of renovation documentation	Building design documentation and as-built drawings (administrator/ contracting entity/archive)	Compilation of renovation documentation can be problematic. Collection of the underlying data is time-consuming as the actual situation does frequently not comply with information provided in earlier building design documentation. Surveying is ordered when necessary.	Renovation documentation	Designer
Renovation	Renovation documentation (designer)	Refer to the description under designing stage.	Refer to the description under designing stage.	Refer to the description under designing stage.
Demolition Conduction of demolishing works requires preparation of demolition documentation and application for respective permit. Critical aspects concern the sequence of demolishing works and utilization/reuse of construction waste.				
Preparation of demolition documentation	Building design documentation and as-built drawings (administrator/ contracting entity/ archive)	Refer to the description under the previous stage.	Demolition documentation	Designer
Application for permit	Demolition documentation (designer)	Refer to the description under designing stage.	Authorization for demolishing the building	Local government
Demolition and utilization of waste	Demolition documentation (designer)	Refer to the description under designing stage.		

3. SUCCESS STORIES AND BEST PRACTICES

3.1. CONSTRUCTION DIGITALIZATION IN THE WORLD

IMPLEMENTATION OF BIM IN SINGAPORE

Singapore is one of the most progressive countries in introducing BIM. Introduction of BIM on the national level started already in 2007. Implementation of BIM has been governed by the Building and Construction Authority that is responsible for regulating the construction industry. **The authority has administered creation of guidance materials for introduction of BIM in organizations and specification of requirements applying to the model. In addition, a BIM fund has been raised**, and it is used for financing training, consultation services and acquisition of software that facilitates collaboration. In parallel with introduction of BIM, several other initiatives have been commenced that are targeted towards increased productivity of the construction sector. One example of such initiatives is the principle of early involvement of public procurers, according to which the project's parties are engaged in the project at an early stage of the project in order to reach the optimum solution and to avoid alterations during the project. Initiatives are also related to sustainable building, environmental friendliness and utilization of innovative technologies. In 2016, the roadmap of research and development needs of the construction sector was published, and it mapped the significant technological directions, including 3D printing, innovative building materials and robotization[27].

Construction and Real Estate Network (Corenet) has been used for applying for building permits since 2011. Use of Corenet has been obligatory for applying building permits for buildings larger than 5000 m^2 from 2015. The system is capable of verifying the compliance of building design documentation that is presented as information model with the provisions of laws and regulations. **Applying for a building permit takes approximately 54 days in Singapore.** In addition to applications of building permits, Corenet also functions as the database of various legal acts and standards that regulate the field of construction.

Pursuant to the experiences of Singapore, utilization of information models on applying for building permits would:

- enable partial automation of application process on the basis of the model of automatic verification of requirements;
- give a better overview of building design documentation to the processing official and/or the coordinating party (neighbors, state agencies, etc).

INTRODUCTION OF BIM IN GREAT BRITAIN

The government of Great Britain has searched for opportunities of reforming the field of construction for decades. The background of reformation is the government's judgement that the construction sector is inefficient and does not operate at full capacity. The government is the biggest individual contracting entity, which provides an unique opportunity for initiating modifications. Strategy document of the construction sector published in 2011 placed emphasis on BIM integration and imposed the requirement that parties of the sector must use BIM Level 2 by 2016, which was determined to be the basis for transition to BIM Level 3.

In order to attain the objectives, BIM working committee was established and funded, and the committee has administered creation of standards, guidance materials and training programmes. The government commenced several pilot projects to obtain first success stories on the experiences of applying the requirements.

A survey regarding utilization of BIM is conducted each year among the companies of the construction

[27] https://www.bca.gov.sg/AboutUs/others/annual_report_17.pdf

sector in order to monitor the progress and to identify the obstacles. Results of the surveys reveal that implementation of BIM has been problematic for many companies, especially when the enterprise did previously not have comprehensive data management. BIM utilization level has raised gradually, and according to the survey of 2018 nearly 75% of the companies use BIM (increase of 12% in comparison with the result of the preceding year) and only 1% of the companies is unaware of BIM. Among the users, approximately 25% of the companies utilize BIM within the scope of just a few projects. The respondents considered the lack of sufficient internal expertise and low demand from the customer side to be the main hindrances of BIM utilization.

Companies are rather critical about the government's initiative, despite the wide-spread implementation. The goal for 2016 was set on performing all public sector projects in completely interoperable 3D information model (Level 2), but only 63% of the respondents agree with the government's demand on using BIM Level 2. Moreover, 62% of the respondents believe that the government will not bring the demand of BIM implementation into force. Subsequently, only 10% of the respondents reckon that the goal set for 2016 has been achieved[28].

In February 2015, the strategic document was published, which stipulated the plan for transition to BIM Level 3. In order to achieve this objective, the Centre for Digital Built Britain was established in 2017. This is a network of participants of the construction sector and research and development organizations that is coordinated by the University of Cambridge.

Estonia could transpose the following important aspects from the experiences of Great Britain:

- Orders of the public sector enable to direct the development of the whole construction sector, but it requires the enactment of the defined objectives.
- Wider strategy of the construction industry would enable to clarify the necessity of BIM introduction and to set the development targets.
- Implementation of BIM requires a coordinating and controlling organization.

Source: Tallinna Tehnikaülikool. Ehitusinfo modelleerimise regulatsiooni süsteemi alusuuring II. 2016

IMPLEMENTATION OF BIM IN FINLAND

Integration of BIM in Finland started in 2002, when the first pilot project was performed by applying the principles of BIM. In 2007, Senaatti-kiinteistöt (State Real Estate Ltd has a similar function in Estonia) issued the first BIM manual. Improved Common BIM Requirements 2012 (COBIM) were published in 2012, and these have also been translated into Estonian. This is a civil engineering guidance material that is not explicitly mandatory, but the guidance material is yet actively used in Finland.

Implementation of BIM in Finland has been endorsed with technology programs of Tekes (Estonian equivalent is Enterprise Estonia (Ettevõtluse Arendamise Sihtasutus; EAS)), and parties of the construction field have developed and introduced technological solutions within the scope of these programs[29]. In addition, KIRA-digi project has been initiated to expedite digitalization of the construction sector and to overcome the hindrances, and its objective is to promote the digital development of the built environment. The vision of the project is to attain an open and reciprocally usable information management ecosystem that would encompass the whole built environment. BIM plays an important role in the project, but the scope of the project is much wider and enfolds also general information management. KIRA-digi is the first project that engages the government, local governments and private enterprises in order to utilize collaboration of various parties in development of interoperable information systems, harmonization of practices and initiation of experimental pilot projects for testing innovative solutions[30].

[28] https://www.thenbs.com/knowledge/the-national-bim-report-2018
[29] Tallinna Tehnikaülikool. Ehitusinfo modelleerimise regulatsiooni süsteemi alusuuring II. 2016
[30] http://www.kiradigi.fi/en/front-page.html

Estonia could transpose the following important aspects from the experiences of Finland:

- Utilization of BIM and other digital solutions presumes gradual improvement of the technological level of the sector's companies.
- Measures used for application of digital solutions should be broad-based, and must involve harmonization of information management, enhancement of legislation and legislation.
- Pilot projects and experimentation were used in KIRA-digi project for obtaining rapid success stories, which has supported achieving the set goals.

3.2. ESTONIAN SUCCESS STORIES IN CONSTRUCTION OF BUILDINGS

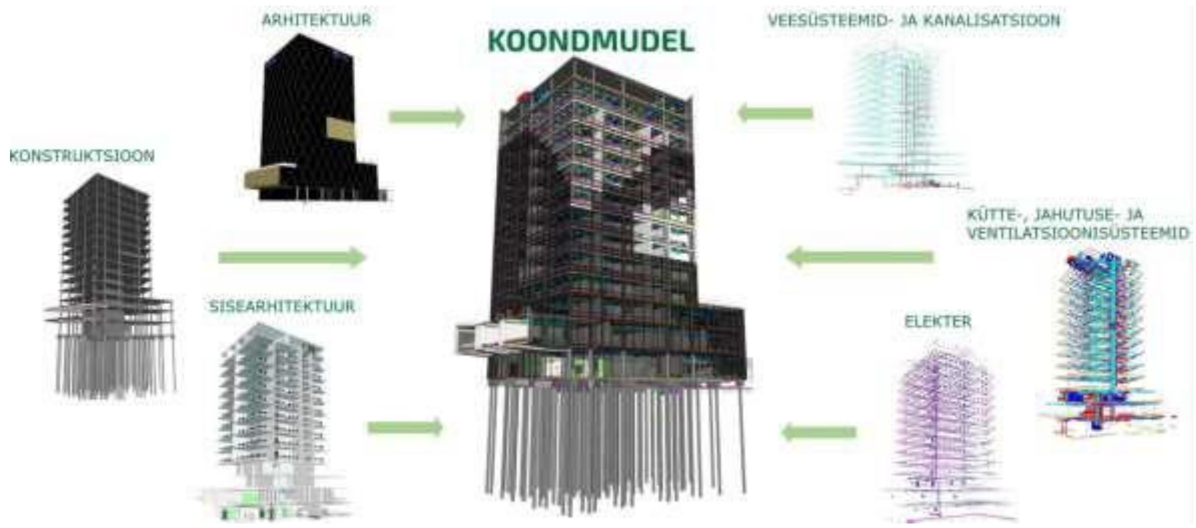
THE TELIA BUILDING

The main success story in the field of digital construction in Estonia is the Telia building that was completed in 2017 and received the best BIM collaboration project special award from the Ministry of Economic Affairs and Communications at the contest of best construction projects of 2018. The whole designing process of Telia building was performed in BIM model. The model project was also used for calculating the construction volumes, managing procurements and planning the works. Architects, engineers, project managers, constructors and contracting entities used BIM models as real-time collaboration platforms from building planning phase until the last meetings of the object. **Utilization of BIM reduced the superfluous work volume of the construction process estimably by 40–60%.**

The project was led by Merko Ehitus, who has been one of the construction industry pioneers in implementation of BIM. The representative of Merko Ehitus explained that BIM model provides the contracting entity a remarkably clearer image of the building being planned and its future operational convenience and enables to plan the forthcoming management costs in a better way. On the other hand, digital construction intrigues the builder with the opportunity of facilitating the collaboration between various parties, forestalling mistakes and saving time and other resources, which altogether raises construction quality to the next level.

Representative of electrical design bureau Melior Projekt OÜ, who compiled the electrical project and the electricity model, confirmed that BIM made the process significantly smoother. All of the communication during designing stage and coordination of the model with other designers was real-time by utilization of Tekla BIMsight software. Trouble-free performance of the works requires well-advised operational processes and input of a BIM coordinator because the building's project manager does mostly not have time for settling all shortcomings in due time[31].

FIGURE 1. SUMMARY MODEL OF THE TELIA BUILDING[32]



[31] https://www.ehitusuudised.ee/uudised/2018/02/21/telia-maja-ehitus-selge-visioon-digiehituse-rakendamisest; http://www.cads.fi/et/paevakohast/uudised/parima-bim-koostooprojekti-auhind-telia-uuele-buroohoonele
[32] Jüri Rass. Kuidas Ehitussektoril läheb (slideshow presentation). 2018

THE BUSINESS BUILDING OF LÕÕTSA 12

BIM was used on construction of the new business building of Technopolis Ülemiste located at Lõõtsa 12 during designing phase and administration of works at the building site. The building was designed by Hevac OÜ and Novarc Group AS, and construction works were performed by Nordecon AS.

Project manager of Nordecon stated that utilization of BIM at the building site disciplined the sub-contractors because none of the sub-contractors wanted to be the cause of potential delays of the project. In addition, BIM enabled to review the critical nodal points and possible hazards with the sub-contractor more efficiently before the building stage. BIM also facilitated making alterations during designing.

Participants explained that cognizant contracting entity played a major role in ensuring the success of the project – the contracting entity engaged external experts in the project, and understood that initial larger contribution into the designing stage enables to save later during the construction works on the account of unexpected costs[33].

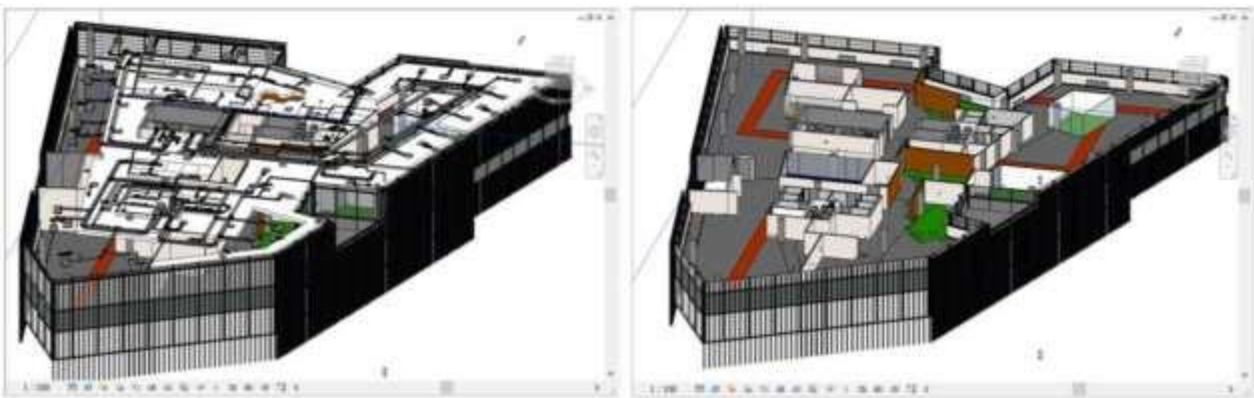
UTILIZATION OF BIM MODEL IN MAINTENANCE OF THE EXPLORER BUSINESS BUILDING

The goal of establishing the Explorer business building in Tallinn that was developed by Capital Mill laid in innovative solutions. The building was designed by AS Skanska and construction works were performed by AS YIT Ehitus. The building was designed in BIM, which was also the basis for creating the as-built model that was the foundation on handing the documentation over to the managing company.[34]

Adaptation of the as-built model to the format necessary for maintenance activities was performed with the researchers of TalTech within the scope of a larger study which was conducted for mapping the opportunities of applying BIM in the maintenance of buildings. The problem on compilation of the mentioned as-built model laid in the fact that the decision of using it in maintenance was made later in the advanced phase of building, and therefore this need was not taken into consideration during designing and construction works. This caused significant additional work on adapting the model and searching for necessary data[35].

Utilization of BIM model in maintenance facilitates orientation in the data remarkably. Therefore it is not necessary to process voluminous documents in order to find specific technical parameters, as the model enables to retrieve the respective section. Consistent updating of the as-built model simplifies significantly future repair and renovation works because the relevant data is readily accessible.

FIGURE 2. EXAMPLE OF USING THE EXPLORER BUSINESS BUILDING AS-BUILT MODEL FOR MANAGEMENT



INFORMATION[35]

[33] http://www.ehitusuudised.ee/uudised/2018/04/20/projektijuht-bim-mudeli-rakendamine-distsiplineerib-objektil-alltoovotjaid
[34] https://www.aripaev.ee/uudised/2016/06/03/arihoone-explorer-pakub-uuenduslikke-lahendusi
[35] Tallinna Tehnikaülikool. Exploration Towards the Development of a Concept and Requirements for FMBIM Information Management. 2016

4. IMPORTANT STAKEHOLDERS

The objectives established within the scope of the vision of e-construction platform contribute to the increase of efficiency of the construction sector and thereby to the raise in productivity, which in turn would contribute to the general welfare growth. Improved information management and movement also contributes to higher quality of the built environment. Therefore, achievement of the objectives established with the vision has significant economical and societal affect.

The construction sector integrates various stakeholders who are influenced by construction digitalization and whose readiness to go along with the changes plays an important role in successful effectuation of the activities. Prerequisite of engaging different parties is an overview of their motivation and factors impeding implementation of the vision. **Attainment of the objectives established with the developed vision is possible only by involving all stakeholders and ensuring their collaboration.** Interests of the representatives of the stakeholders may be controversial between and inside different groups, and the developed vision should take this into account.

The following overview describes the main stakeholders, their role in the building's life-cycle, expectations on the vision and main obstacles of integrating the innovative solutions today.

CONTRACTING ENTITY/OWNER

The contracting entity initiates the construction process. The category of contracting entities includes contracting entities who place a single order as well as professional developers. Development and digitalization of the construction sector has to reckon with the needs of contracting entities of both levels, and keep particularly in mind that the process should not become too complicated for private contracting entities. One important prerequisite of achieving the objectives established with the vision is raising the competence and awareness of the contracting entities in order to encourage them to require and utilize digital solutions. On the other hand, the contracting entity is the one who could gain the most from implementation of BIM.

INTEREST/ROLE

The contracting entity initiates the whole process on the basis of respective needs. Contractual relations enable to ask for utilization of novel solutions and collaboration structures.

The main interest is to receive with optimal cost a high-grade result that complies with the needs.

HINDRANCE

The contracting entity has least professional knowledge in the value chain. The contracting entity has to have a lot of trust in the service provider, and thereat it is difficult for the contracting entity to evaluate the quality of the performed works.

Because of insufficient professional knowledge, the contracting entity does not have a comprehensive overview of the whole construction process and is incapable of assessing how costs/activities incurring in one stage affect the activities/costs of the next stage. Another aspect concerns the wide-spread notion that utilization of BIM makes the process more costly across the life-cycle.

Implementation of BIM requires higher awareness and control of the contracting entity throughout the process, which in turn entails additional (time) resources from the contracting entity.

EXPECTATION

Utilization of digital solutions gives the contracting entity a better overview of the object being built: 3D extracts and virtual reality solutions provide a more comprehensive perception of the final result. Partially automated budgeting of higher quality gives a more precise outline of the expenses (in terms of construction costs and expenses incurring throughout the life-cycle). As for competitions, introduction of harmonized standards (classification) would make the tenders comparable with each other and the initial brief.

Utilization of automatic verification on proceeding building permits and use and occupancy permits expedites the process.

Implementation of digital solutions makes the whole process more transparent and controllable for the contracting entity.

When the building is ready, the contracting entity will have the digital twin of it.

Public procurers as parties with significant market power are discussed separately below, because they play a vital role in imposing innovative solutions.

INTEREST/ROLE

These contracting entities have significant market power and are therefore capable of guiding the behavior of other market participants.

It is possible to influence other contracting entities through success stories and by sharing best practices.

The goal is efficient and transparent use of the financial resources of the public sector.

HINDRANCE

Risks and restrictions that derive from the complexity of arranging public procurements do not promote the use of innovative solutions. Line of least resistance results in choosing the cheapest offering.

Budgetary periods and political interests cause the present problem of hastening in each stage (compilation of procurement documents and the initial brief, designing, building).

Professional awareness and experiences are insufficient (except for State Real Estate Ltd, Estonian Road Administration).

EXPECTATION

Implementation of digital solutions makes the process more transparent and facilitates its administration. The costs are more predictable and reasonable to the public.

More transparent processes and input data of higher quality reduce the problems related to making sub-offerings on public procurements, where the objective of companies is to exploit the errors in input data in order to maximize their profit.

COMPANIES OF THE CONSTRUCTION SECTOR

Another important category and group of beneficiaries involves the enterprises related to the building's life-cycle: particularly the designers, builders and administrators. Implementation of the developed vision would improve data exchange and collaboration between the companies in addition to facilitating data management.

INTEREST/ROLE

Efficient movement of work-related data of high-quality, which enables to optimize operational processes.

Smooth and transparent communication with local governments and state institutions.

HINDRANCE

Not all companies of the sector have interest in applying novel solutions and going along with innovation.

Implementation of BIM involves a large initial investment. Companies are frequently incapable of assessing the profitability of the investment.

Digitalization presumes major alterations in the organization and processes, majority of the companies is not ready for management of changes.

Companies do not have resources and motivation for introducing new methods because of major fragmentation of the sector and the proportion of microenterprises (increase in efficiency is expressed in collaboration).

EXPECTATION

Higher availability of input information (in a processable format) reduces time burden and errors in building design documentation.

The model provides a good collaboration platform throughout the construction process.

Creating a fast and efficient opportunity for communicating with the state reduces time spent on proceedings and promotes implementation of innovative solutions.

The goal is to decrease project-related uncertainty, which would reduce the risks and increase the aptitude of process management that in turn would help to raise efficacy. This would result in higher margins and work quality of companies. New data-driven (supplementary) services would enable to offer additional value to the contracting entity. Examples include automatic budgeting of changes in the construction process or binding the financial account with the building's model. On the other hand, the sector's companies can militate against implementation of the developed vision if they do not consider that it would bring enough benefit for them. Main hindrances to introduction of innovative solutions lay at the moment in significant fragmentation of the sector (large proportion of microenterprises and small enterprises) and insufficient collaboration between the parties, culture of work and low technological capability.

LOCAL GOVERNMENT AND THE STATE

Different participants have several encounters with the local government during the building's life-cycle. This includes applying for permits, fulfilment of surveillance requirements and requests for input information (planning documents).

INTEREST/ROLE

Major information possessor has the capability of controlling the form and content of the presented data.

HINDRANCE

One of the biggest obstacles of today is the officials' variable technical competence and motivation for altering operational processes.

Proceedings of projects are often not substantive because of the large volume of the presented data, and inspection is limited only with formal verification.

The practices used by local governments and state agencies are very different. Processes are not harmonized to an adequate extent.

EXPECTATION

Utilization of information models that are prepared on uniform grounds enables partial automation of data verification for example on applying for permits, which would relieve the official from routine duties and allow to focus on substantive analysis.

One goal involves simplified information management. It is easier for the official to orientate in the model than in distinct files.

Utilization of digital solutions would ensure better visualization of the object being built, which would enable to analyze more efficiently its fitness into the environment.

EXTERNAL PARTIES OF THE LIFE-CYCLE

In addition to direct participants of building's life-cycle, the vision of e-construction also affects external parties of the life-cycle. Examples include manufacturers of building materials and utility network operators who have an important role as creators of the input information.

MANUFACTURERS OF BUILDING MATERIALS

- One prerequisite of BIM implementation is the existence of product catalogues. Separate modelling of each product/element requires resources. One option is establishing central banks of elements. Manufacturers of building materials might be interested in modelling the elements as they form a part of sales material (the designer adds into building design documentation the ventilating apparatus that he/she finds from the database). In addition to direct technical parameters, it is possible to supplement the modelled element with additional information, such as certificates of conformity and performance or maintenance instructions.
- Utilization of the information model might facilitate preparations for the manufacturing process of factory-produced elements (geometry and volumes of the necessary elements could be automatically extracted).

UTILITY NETWORK OPERATORS

- Conditions of integrating with utility systems must be taken into account on designing, and approval has to be obtained from the operator for applying the building permit. As of today, these data are fragmented between network operators, and data are not readily accessible and must be retrieved with a separate request. The level of details of solutions that network operators demand for giving the approval frequently equals with operational building design documentation (compare with the rest of the building design documentation prepared at preliminary building design documentation stage).

- Operators of utility systems lack a precise machine-processable overview of their infrastructure, which complicates digitalization of data.
- At the moment, a charge can be asked for the release of technical conditions, which lowers the motivation for automatizing the process.

Another important category of stakeholders of developing the platform is the general public that wishes to examine the surrounding built environment and its developments.

PUBLIC INTEREST

- Utilization of BIM and aggregating information about buildings to an e-construction platform enables better visualization and management of the information (for non-sectoral parties). Therefore, interested parties can get a more comprehensive overview of the built environment and its developments.
- Digitalization of the construction sector and the e-construction platform under establishment increase transparency of the construction sector, and create a more integral view of the building under construction. This gives reason to expect an overall raise in the quality of the built environment.
- The objective of increased productivity of the construction sector enables to expand competitiveness of the sector, which in turn contributes to the general welfare growth.

5. MOST IMPORTANT FIELD-SPECIFIC NATIONAL STRATEGIC DOCUMENTS

Construction activities are regulated with various field-specific laws and other legal acts in addition to utilization of standards of Estonian Centre for Standardisation and international standards. The development of the construction sector is directed by strategic documents and development agendas of Estonia and the European Union. Therefore, development trends described in strategic documents must be taken into account on creating the vision, and it is also necessary to analyze conformity with field-specific legal acts. This chapter gives an overview of the main legal acts and strategic documents. More specific hindrances of implementing the vision are provided in the vision paper.

FIELD-SPECIFIC LEGAL ACTS

The Building Code and the Planning Act are the principal laws governing the field. In addition, several regulations of the Government of the Republic and the Minister of Economic Affairs and Infrastructure have been enacted ("Formal requirements of notifications, building permits, use and occupancy permits and their applications and the procedure of submitting notifications and applications", "Requirements applying to road building design documentation", "Requirements for building design documentation", "Requirements of the expert assessment of building design documentation", "Constitutive regulation of the register of construction works", "Requirements of documenting construction works, preservation and transfer of construction documents, and requirements applying to maintenance instructions and their retention and submission").

Legal acts governing the field do not promote the introduction of digital solutions, but also do not impede it directly. **Legal acts have not been compiled in view of the logics and processes of digital solutions**; regulations do refer to digital documents, but in majority of the cases they do not differ substantially from documents on paper media.

Main Estonian legal acts concerning the field of construction and planning do not reflect nor govern the need or requirements of preparing building information models. Regulation "Requirements for building design documentation" mentions utilization of 3D models in general term, and permits to add virtual models or 3D models to building design documentation. Regulation "Requirements of documenting construction works, preservation and transfer of construction documents, and requirements applying to maintenance instructions and their retention and submission" stipulates that IFC information models and formats should be used on preparation of a digital model of a building.

Public Procurement Act governs the role of the public sector as a contracting entity with significant market power. Criticism on public procurements often refers to the fact that the utilized **criterion of the lowest price does not favor innovation or use of novel solutions**. Hereby it is important to note that Public Procurement Act does not oblige to choose the offer with the lowest price. Public Procurement Act stipulates that offers should be assessed on the basis of economic advantageousness. This principle includes various object-related criteria, such as quality, price, technical value, esthetic and functional properties, environmental characteristics, operating costs, profitability, after-sales maintenance and technical support, delivery date and deadline of supply or completion of the tender. **Preference of price-based criteria is very wide-spread in practice.** There are many reasons for it – for example, limited financial resources of contracting entities, fear of procurement contestation on using more complex assessment criteria that leave room for interpretation, and professional competence and experiences of the parties preparing the procurement.

FIELD-SPECIFIC STRATEGIC DOCUMENTS

The agenda of competitiveness "Estonia 2020"[36] and the strategy on sustainable development "Sustainable Estonia 21"[37]

36 https://riigikantselei.ee/sites/default/files/content-editors/Failid/eesti2020/ee2020_tekstiosa_2018- 2020_heaks_kiidetud_26.4.2018.pdf
37 https://riigikantselei.ee/sites/default/files/content-editors/Failid/saastev_eesti_21.pdf

The developed vision contributes to achieving the following goals defined in the agenda of competitiveness "Estonia 2020" and the strategy on sustainable development "Sustainable Estonia 21": increased competitiveness of economy, improvement of the well-being of citizens and enhancement of state governance.

Construction has significant influence (employment, proportion of gross domestic product), and a sector with low productivity has crucial importance from the viewpoint of attainment of the objectives established in the mentioned strategy papers. The goal of the developed vision is to reduce time burden and quality-related problems in the construction sector by optimizing information management and improving operational processes, which in turn raises productivity of the construction sector.

The digital agenda[38]

The vision contributes to achieving the sub-goal of Estonian digital agenda, which is smarter state governance. It provides the citizens and entrepreneurs with services that are non-cumbersome and convenient and have been co-created. Reaching this target means higher (cost-)effectiveness, and heathier and more open functioning for the public sector itself. The digital agenda stipulates that the public sector will go through transition to paperless administration and integrated information management. This enables to attain the sub-goal of smarter state governance, and to increase the influence and cost-effectiveness of public services.

Growth areas of smart specialization[39]

The developed vision of e-construction platform contributes directly into achieving the priorities of smart specialization. The vision supports the first growth area of smart specialization, which is **application of information and communication technology (ICT) horizontally through other sectors – in the given instance the construction sector**. It also contributes to the subfield of the third growth area of enhancement of resources, which is knowledge-based construction. The report of knowledge-based construction compiled by Estonian Development Fund lists the following goals: bigger added value per employee and higher digitalization of operational processes across the building's life-cycle.

National spatial plan "Estonia 2030+"[40]

The main objective of national spatial plan "Estonia 2030+" is directing spatial development in most general aspects. The main target of the plan is balanced and sustainable development of settlement, which presumes establishment of diversified social and economical environment that is grounded on the existing settlement structure and provides various alternatives. National spatial plan provides general guidelines for preparing county plans and comprehensive spatial plans of local governments.

The vision contributes directly to the attainment of the objectives defined in the national spatial plan. The platform under establishment aggregates all information on the built environment and enables to visualize it. Improved availability of the underlying data helps to make more conscious decisions on spatial planning.

Estonian development plan of the energy sector "ENMAK 2030"[41]

Estonian development plan of the energy sector "ENMAK 2030" establishes the objectives for ensuring sustainability of the building stock and reducing the power requirements of buildings. Current pace of renovating buildings and constructing new buildings is too slow on the basis of the development plan. Also, it is necessary to pay attention to energy efficiency of buildings and assurance of indoor climate. Attainment of the mentioned goals presumes increased productivity of the construction sector and the quality of building design documentation. The developed vision addresses both fields.

Europe 2020 strategy and the sub-strategy of construction sector competitiveness[42]

The developed vision complies with Europe 2020 strategy, which is targeted towards the growth of

38 https://www.mkm.ee/sites/default/files/elfinder/article_files/eesti_infouhiskonna_arengukava.pdf
39 http://ns.arengufond.ee/ressursside-vaarindamise-raport
40 https://www.rahandusministeerium.ee/sites/default/files/Ruumiline_planeerimine/eesti2030.pdf
41 https://www.mkm.ee/sites/default/files/enmak_2030.pdf
42 https://ec.europa.eu/growth/sectors/construction/competitiveness_en

economy and employment. The strategy places emphasis on the importance of smart, sustainable and inclusive economic growth that enables to overcome the structural weaknesses of European economy, and to increase competitiveness and productivity. Within the scope of Europe 2020 initiative, the European Commission conduced the compilation of strategy of sustainable competitiveness of the enterprises of the construction sector. The strategy focuses on five domains:

- Digitalization and investments
- Skills and qualifications
- Resource efficiency
- Regulatory framework
- International competition

The developed vision contributes directly to the sub-goal of digitalization.

Circular economy action plan[43]

Circular economy action plan of the European Union influences business sectors, including the construction sector. Implementation of circular economy principles in construction presumes a more comprehensive approach to buildings and the materials used. This includes optimization of maintenance need across the building's life-cycle and recycling of the materials deriving from demolition. In addition, it is important to reduce waste and alterations during construction. More integrated approach to the building's life-cycle that is achieved by utilization of digital solutions supports achieving these goals.

[43] http://ec.europa.eu/environment/circular-economy/index_en.htm