Open BIM technologies in Russia

Usage and development of Open BIM in Russia

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Abstract

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Abstract

BIM-ICE project standing for BIM education development has launched a survey aimed to explain how BIM and Open BIM technologies used in Russian Federation. This research explains the basic points of BIM such as BIM standards, use cases, team, structure, levels and dimensions. The explanation is made for those who don`t understand the basics to make the research open for everyone who is involved in the construction industry someway or just wants to.

The results of the research are listed at the end of the thesis and fully describe the formats of BIM usage, software and process that is used in the Russian construction market. The main results can be interesting for those who wants to know in which direction the BIM development in Russia is going.

The main results of the surveys are briefly explaining the aim and some key points. The most widespread disadvantage of BIM is the high implementation cost. The most popular reason to implement BIM is project quality improvement. The most popular BIM programs are Revit and Navisworks. The main part (66%) of responders uses the IFC format in their work.

BIM and Open BIM as a part of it are used worldwide and also in the Russian construction market having the potential to widespread. Russia is a big country and will implement a lot of big projects in the future across the big territory.

Keywords

Building Information Modelling, management, Open BIM, survey, analysis

Contents

1 Introduction

Every day the world is going forward developing new technologies and approaches to make our life better, more interesting and healthier. Technologies affect all the spheres of our lives making it easier. Building and construction is a part of our lives we mostly affected. The development of new technologies and an IT-sphere has changed all the construction industry for the last few decades.

This thesis is about the development of Open BIM technology in the Russian Federation. Since BIM was implemented a lot of building design methods were created based on it. Open BIM technology is the way of collaboration between engineers, architects, clients and/or other stakeholders of the project based on Building Information Management standards.

The purpose of the thesis is to explain the main points of BIM workflow on the international level and show the level of BIM and Open BIM usage in Russia. This thesis will explain how this technology is implemented in Russia, which software is used according to the survey results and how this technology actually works. The theoretical part of the thesis is mostly based on international standards.

Surveys were developed by Saint-Petersburg State University of Architecture and Civil Engineering (SPbGASU) within the BIM-ICE project. Two surveys were developed: for educational organizations and construction companies. All the questionnaires were created using the Google platform. The thesis analyses the survey of construction companies. According to this survey results the report mostly describes the status of BIM and Open BIM in Saint-Petersburg.

This work will be helpful for students, teachers, university authorities, employers and employees. Students can find information about what is Open BIM in Russia and which software is demanded. University authorities and teachers will find out how new technology is implemented and will be able to explain new methods to students. Employers and employees can be interested in the statistic among the Russian construction market to choose an optimal growth strategy or training direction.

The thesis is a part of a complex research program initiated by the BIM-ICE project within the first package of the project. BIM Integration in Higher and Continuing Education called the BIM-ICE project is aimed at acceleration of BIM implementation in the field of construction and building design in Finland and Russia.

2 BIM Integration in Higher and Continuing Education

BIM-ICE Project standing for “BIM Integration in Higher and Continuing Education” seeks to accelerate BIM implementation in the field of construction and building design in Finland and Russia. Addressing such topical issues as lack of common terminology in the field and development phase of standardization, lack of technical know-how and lack of competence in process development, the Project is aimed at improving productivity and quality within the construction industry by developing new training models and increasing the level of education among different target groups. At the end of 2019 it got funding within the 5th round of cross-border cooperation program “South-east Finland -Russia CBC 2014-2020”. (BIM-ICE Project 2020)

Figure 1. BIM-ICE logo (BIM-ICE Project 2020)

2.1 Project goals

The two main goals of the project are:

1. to increase the level of knowledge among the students and the professional community in the field of BIM technology
2. improve the educational process that will guarantee the high qualification of young professionals in the construction industry (BIM-ICE Project 2020)

Target groups of the project: students, experts and teachers, professionals, Finnish and Russian construction companies and decision-makers. (BIM-ICE Project 2020)

2.2 Expected results

From a long-term perspective, the BIM-ICE project is going to achieve the sustainable methodological support of BIM implementation in higher, professional and the continuing education process through:

a) developing pedagogical approaches to BIM education
b) creating a digital open-access platform of collected and produced materials for professionals and decision-makers on different levels
c) continuity in education and development via educating HEI staff in BIM philosophy and technicalities (BIM-ICE Project 2020)

2.3 Collaboration with companies

BIM-ICE project aims at improving the productivity of the building industry by developing new skills and competences as well as methods that support digital tools usage. Companies and organizations are one of the target groups because their current needs and industry trends form the content of future BIM education. (BIM-ICE Project 2020)

Roles that companies can have in the BIM-ICE project:

- Participating in the project pilot BIM courses
- Promoting your software and company services
- Providing actual topics for students' research and final thesis
- Taking part in project seminars, workshops and conferences
- Giving tasks for project development for students (BIM-ICE Project 2020)

Benefits for companies:

- New pilot BIM courses and learning materials
- New possibilities in the fields of BIM research, development and implementation
- The new professional communication network in Finland and Russia
- Promotion of the company
- Education for the staff of the company
- Scouting for most talented students as future employees of the organization
- Joint BIM pilot projects (staff and students work together) (BIM-ICE Project 2020)

2.4 Key facts about the project

The BIM-ICE project is funded by CBC in the amount of 479 690 € and lasts from 01/04/2020 till 30/09/2022. The lead partner of the project is LAB University of Applied Sciences (https://lab.fi/fi) in a partnership with SPbGASU (https://spbgasu.ru/en). (South-East Finland-Russia CBC 2014)

3 Building Information Modelling

> *Evolution of BIM implementation came in parallel with a willingness to collaborate and share project information, the move toward an integrated practice that is much talked about in the industry. (Bernstein)*

Building Information Modelling, Model or Management (BIM) is one of the most perspective new technology in the engineering, architecture and construction industry. Behind the BIM technology is a digital model that combines information and parameters related to building shape, structure and system. Ready building informational model carries precise geometry and relevant data required to support the design, procurement, fabrication, and construction activities necessary to complete the building. After the commissioning, the digital model can be used for building management. (BIM Design Hub.)

The following research is made using different standards including international. Because such technology is used worldwide and despite the development of international standards in different countries it has unique appearances that rely on local construction practice.

3.1 BIM definitions

There is no universal definition of BIM that would be accepted by the worldwide BIM-users community. Nevertheless, there is a wide range of definitions of BIM from different organizations and institutes. The reason for this is that BIM technology is constantly evolving; however, there have been some useful definitions provided below: (BIM Design Hub.)

> *Building Information Modeling (BIM) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. (Autodesk.)*

> *Building Information Modelling (BIM) is a set of technologies, processes, and policies enabling multiple stakeholders to collaboratively design, construct and operate a Facility in virtual space. As a term, BIM has grown tremendously over the years and is now the 'current expression of digital innovation' across the construction industry. (BIM Dictionary 2021.)*

> *BIM is the construction of a model that contains information about a building from all phases of the building life cycle. (ISO 16757-1.2015.)*

BIM is a shared digital representation of physical and functional characteristics of any built object (including buildings, bridges, roads, tec) which forms a reliable basis for decisions. (ISO 29481-1:2017.)

BIM is an environment that offers several platforms to connect all the built asset (building, district, city, country) lifecycle phases in a digital way by using 3D modelling, programming, reality capture technologies, data processing, artificial intelligence and analysis tools. (By author Richard Kurilov)

Among the big amount of definitions it is important to understand that all definitions emphasise different aspects of BIM concerning the process, technology and people, but also they all share some similarities: (BIM Design Hub.)

- The model itself, as a digital appearance of physical and functional characteristics.
- The process of developing the model; hardware, software, data exchange, workflows, collaboration, definitions of roles and responsibilities, etc.
- The use of the model; business models, standards, deliverables during the project lifecycle, collaborative practices. (BIM Design Hub.)

3.2 BIM usage

Working in construction a lot of engineers encounter problems with the project information management and taking the information off. BIM is one of the best decisions for it in many construction activities. (Liucci 2021.)

3.2.1 Visualization and troubleshooting

BIM is based on taking the information from the model. The model creating process allows you to see how the building will appear and perform after completion (As-Built model) and spot any potential problems in the early stage. That allows engineers to make more informed decisions and essential changes on time before it will become a significant delay or cost rising reason. (Liucci 2021.)

3.2.2 Cost estimation

Correctly selected and well set BIM software can organize a complex cost estimation task that until now needed to use different apps and formats. BIM tools are quite accurate in it. When any feature, if the model has changed the cost estimation, will update as well. This fully automated process can save plenty of time for engineers. (Liucci 2021.)

3.2.3 Exploring different solutions

In the past architects and engineers had no way to visualize and try all the possible options. Today right BIM software allows exploring different solutions by changing some parameters that will reflect on the model and let you choose the perfect decision. It is called bi-directional associativity. (Liucci 2021.)

3.2.4 Facility management

BIM is supporting the project within the building lifecycle so it can be used even after commissioning. The owner can use the model for the operation and maintenance of the building. BIM model is a building data source that contains information about floor plans, cross-sections, details, materials and cost. This information can be handy years after the building commissioning. (Liucci 2021.)

3.2.5 Project coordination

BIM stores all the details about the building in one place – model. Easy access to the model can be reached by using cloud sharing so every member of the team can have access to significant data and update it anytime. The changes will be visible immediately. (Liucci 2021.)

3.3 BIM structure

Building Information Modelling is about the operation the building through the lifecycle. Like every building, BIM has its structure that represents a complex of requirements, technologies, methods and standards that connect stakeholders. This complex regulates the BIM lifecycle providing the exchange of updated information between stakeholders. Figure 2 shows the BIM structure within the built asset lifecycle. (PBC Today 2018.)

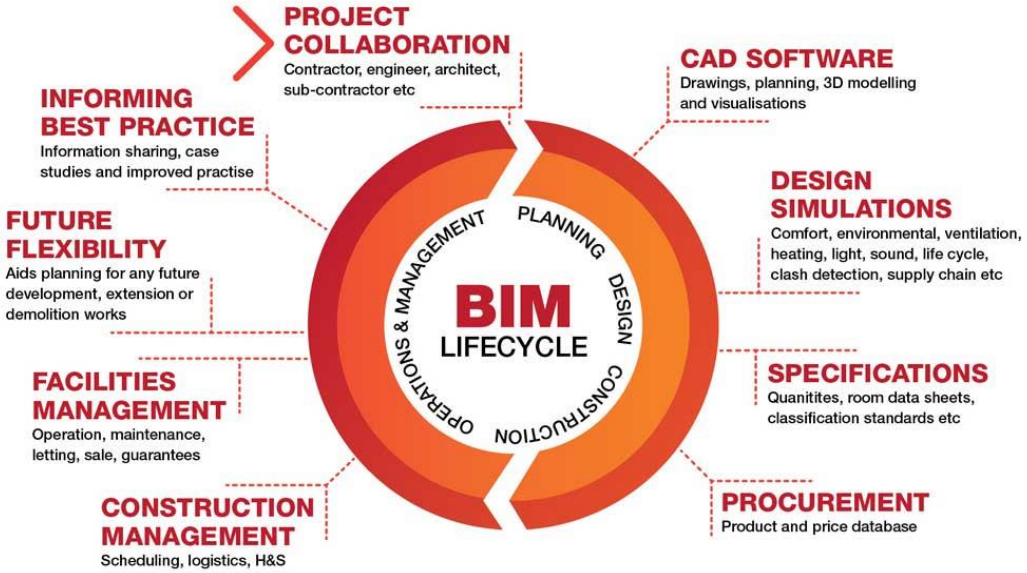

Figure 2. BIM lifecycle (PBC Today 2018)

3.3.1 Information requirements

BIM information requirements are needed to support model-based project delivery and asset management.

- Exchange Information Requirements (EIR)

EIR is a document made by the client and based on BIM standard where all the requirements for project information are listed. The main goal for EIR is to describe the requirements and how to manage the information in the specific project. It is important to understand that EIR is one of the main documents along with the rest of the tender documents that regulate the partner and contractor selecting process and during the tenders or competitions. EIR simplifies project stakeholders collaboration and due to EIR all the partners will clearly understand what the client needs. (BIMLAB.)

- Organizational Information Requirements (OIR)

OIR describe the information required by and organization for asset management and organizational functions. That is an organizational-level information requirement rather than a project-level of asset-level information requirements. (Professional Construction Strategies Group.)

- Asset Information Requirements (AIR)

AIR describes the information that is needed to operate and maintain a built asset (building, multiple buildings) according to the organization`s asset management strategy. AIR is a part of the Building Information Modelling process that defines graphical or non-graphical information and documentation required for the lifetime operation and management of a built asset. (Professional Construction Strategies Group.)

- BIM Execution Plan (BEP)

BEP`s mission is to provide teams with a guideline about how BIM gets implemented on a project. This is a part of support documents that help the construction industry in delivering lifecycle BIM. The BIM Execution Plan is a bridge between EIR (describes what the client wants from BIM) and in-house BIM standards (define the BIM structure within individual organizations). (Holzer 2016, 125 - 126.)

- Project Implementation Plan (PIP)

PIP is a plan that describes how the project will be implemented. Here is explained how the designers will implement BIM-project according to the EIR and BEP. PIP cannot be the same for other projects. (Rogachev 2015)

The figure below represents the relationships between information requirements (OIR, AIR, AIM, EIR, PIM) that are described above.

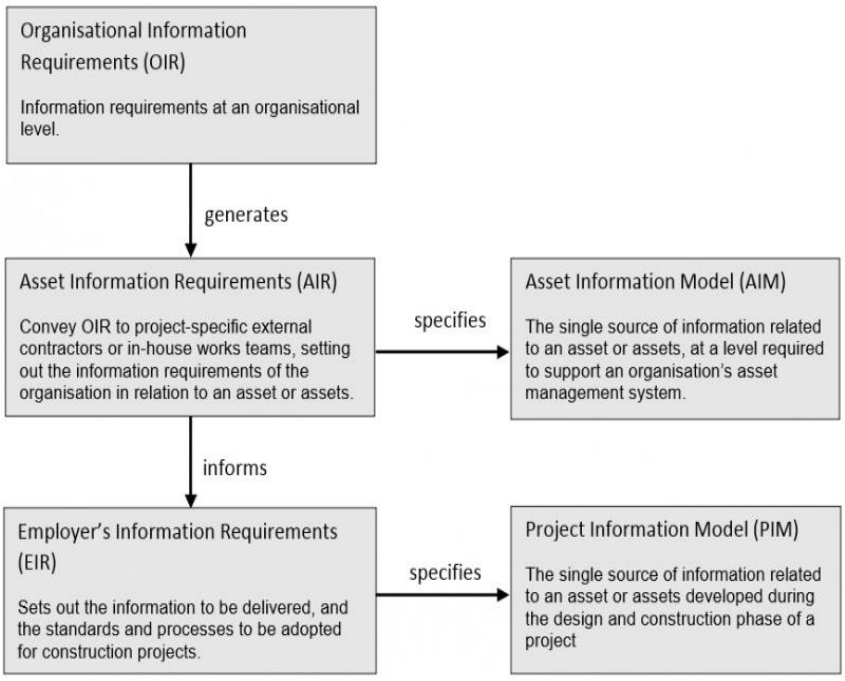

Figure 3. OIR AIR EIR relationship (Professional Construction Strategies Group)

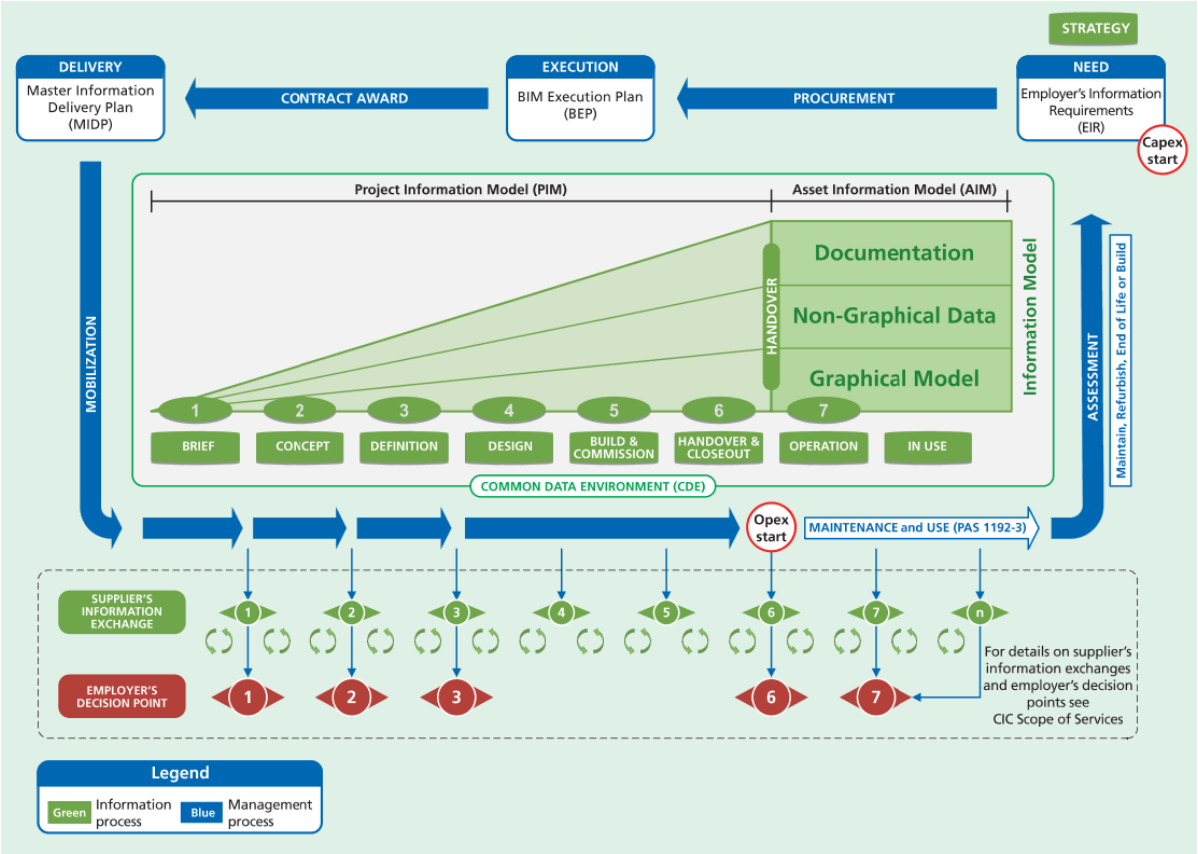

Figure 4. BIM documentation (ISO 19650)

Figure 4 shows in which phase different BIM documents and information standards are used.

3.3.2 Information models

Building information modelling is divided into 2 categories: creating (changing) asset activities and asset management activities. The figure below shown the BIM model development within different phases. Phases are kind of levels of model development that have to meet special requirements of the asset management process.

Figure 5. The information model and project phases (Bbcarchitects)

- Project Information Model (PIM)

PIM is an Information model developed during the designed and construction phases of the project. This is an asset creation process. All the requirements for PIM are listed in EIR. (Professional Construction Strategies Group.)

- Asset Information Model (AIM)

AIM is a term that describes a set of information collected from all sources that support the asset (building, multiple buildings) management. The AIM serves as a single source of essential and approved information that is related to a built asset and is needed during the operational phase of the building (asset). (McPartland 2017.)

3.3.3 Collaborative practices

Building design and construction projects always need an established collaborative practice because they involve bringing together a large number of diverse disciplines that have not worked together before. The coordination and integration of a great deal of complex information, procedures and systems are also involved.

- Common Data Environment (CDE)

CDE is central storage where project information is located. Apart from information created in the BIM environment, it includes documentation, graphical model and non-graphical assets. Using a single source of information collaboration between project members should be improved, mistakes reduced and duplication avoided. (McPartland 2016.)

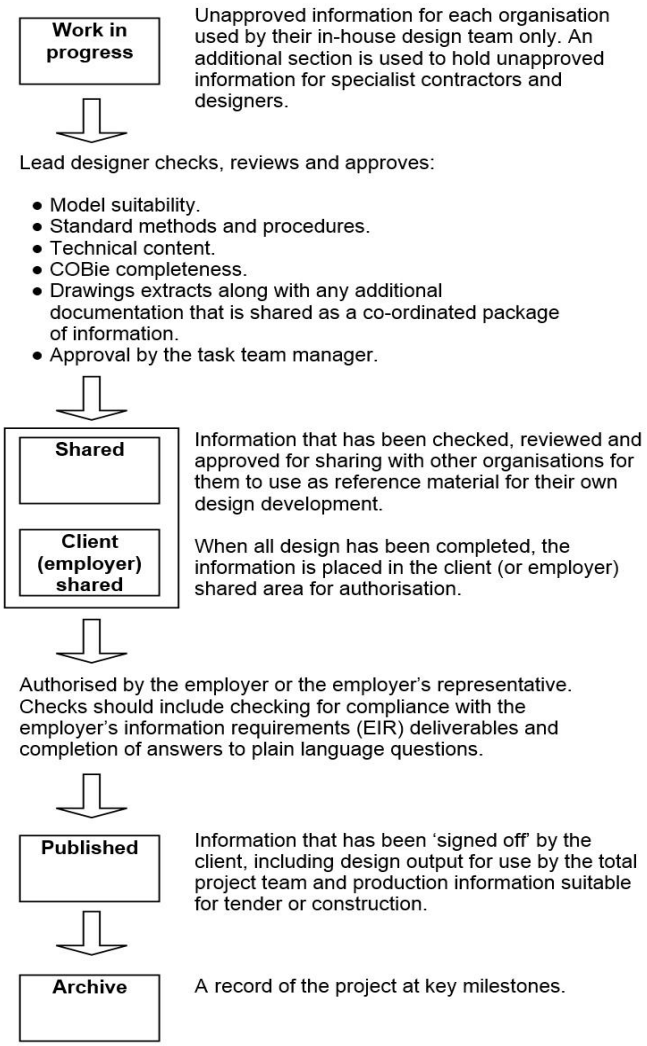

Figure 6. Typical CDE working process structure (Professional Construction Strategies Group)

Figure 6 shows the typical BIM workflow in the case of using CDE. It is a common method of collaboration across the BIM projects in the construction industry.

- Industry Foundation Classes (IFC)

IFC " is a standardized, digital description of the built environment, including buildings and civil infrastructure". This is an open international standard (ISO 16739-1:2018). This standard is vendor-neutral so that a lot of hardware devices, software platforms and interfaces can use it for many different cases. (BuildingSMART.)

- Construction Operations Building Information Exchange (COBie)

COBie is a construction operation building information exchange format. It can be also described as a specification of all of the spaces and equipment in a building. This format contains information about assets and equipment as well as how this information should be exchanged. (East 2014.)

- Uniclass

Uniclass is an optional classification system for the construction industry that can be used to organize information throughout all the aspects of the design and construction process. Interoperation between different systems can be simplified by adopting a standard classification. (Professional Construction Strategies Group.)

3.3.4 Level of development/details (LOD)

This term is divided in two parts:

- The level of details is the way how the model looks. The level of model detail. For example specific shapes and measurable locations inside the model.
- Level of development refers to the accuracy and reliability of the model. For example: whether the pipes in a model have been engineered and the permanence of their placement. (Reis 2017.)

LOD is a common reference. This document where different levels are listed can be freely downloaded and accessed. This standard can help to consider the level of detail as a criterion of the level of development. The more the component is developed then more details are provided too. (Reis 2017.)

3.4 BIM levels

BIM levels are a set of accepted criteria to determine the degree of compliance of the BIM project process with the technology. (McPartland 2014.)

- BIM Level 0:

This step represents the simplest forms of collaboration. Production and exchange of information are taking place by using papers and non-interoperable electronic documents. CAD drawings are used but no sharing of generated information models. (Marketing ACO.)

- BIM level 1:

This typically includes a 3D CAD for concept work and 2D for drafting and production information. CAD standards are referred to BS 1192:2007 and a common data environment (CDE) is used for digital data sharing. CDE is often managed by a contractor. (McPartland 2014.)

- BIM level 2:

This level is described by more organized collaboration - everyone uses their 3D models but working in a single common model is not a key feature of this level. Collaboration is ensured by the streamlined data exchange process being a defining aspect of the second level of BIM. The project data is published in an available file format, which allows every member of the project to combine this data with their developments, and then create an integrated BIM model (Federated BIM model). Each project participant has his own integrated BIM model what I used for overall coordination and verification of design solutions. Therefore, all the kinds of software used by the project members should be able to export the data in available formats such as IFC or COBie. (Marketing ACO.)

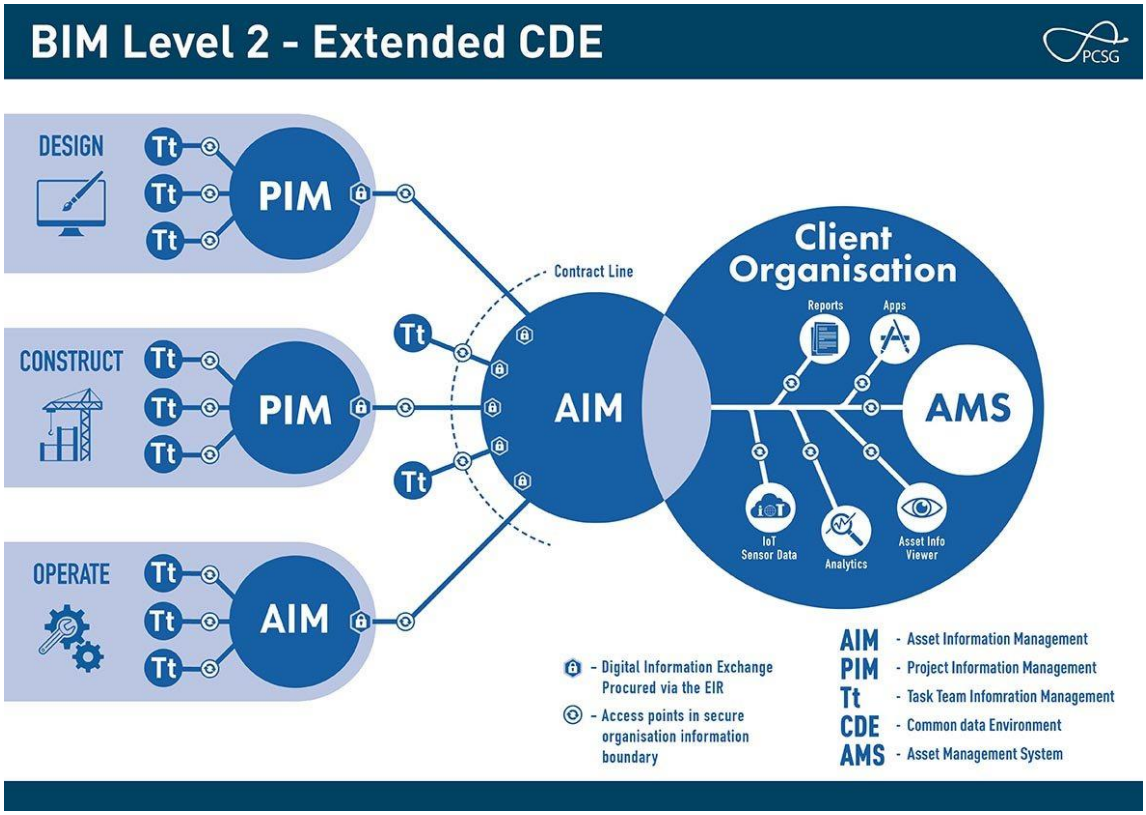

Figure 7. CDE content and members within the BIM level 2 (PBC Today 2016)

Figure 7 shows the interoperability of the PIM, AIM and client within the common data environment.

- BIM level 3:

The third level represents close interaction between all disciplines by using a single, common project model located in a central data storage. All the project members can have access to the central model and work in the same model. The benefit of this technology is that it excludes the appearance of conflicting data. This level is known as "Open BIM" (McPartland 2014.)

The interaction between processes, tools and BIM standards within BIM levels is shown in Figure 8.

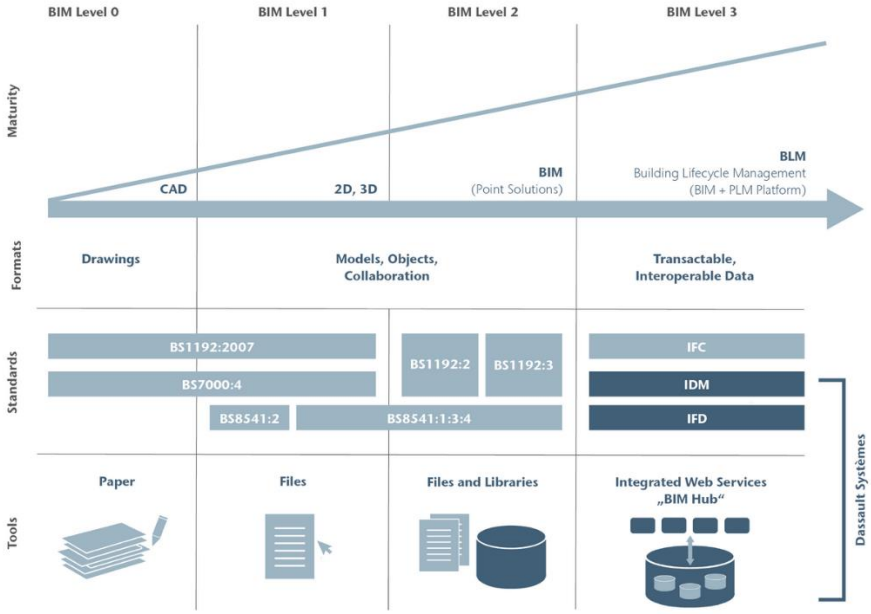

Figure 8. BIM levels (Marketing ACO)

3.5 BIM team and roles

Building Information Management requires a couple of qualified specialists working together within the BIM team as shown in Figure 9.

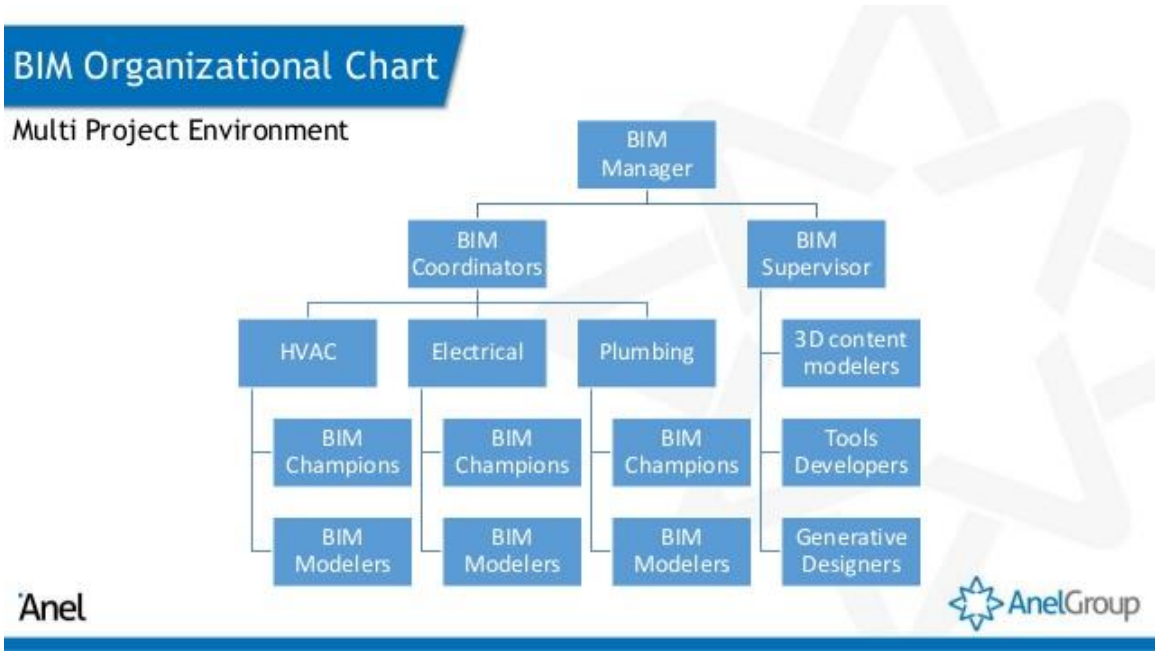

Figure 9. BIM team (Anel Group 2017)

3.5.1 BIM manager

BIM manager is a Civil Engineer who is responsible for Building Information Modelling and Data Construction procedures during all the phases of the construction project. BIM manager`s duties vary across many organizations and depend on the size of the project and the size/competences of other BIM engineers. (Institution of Civil Engineers.)

BIM manager has a responsibility for a team to be sure that the project goes accurately and according to the required specifications. BIM manager works closely with BIM technicians who are responsible for technical drawings and information models production. (Goconstruct.)

Typically BIM managers have the following duties:

- To be a mediator between designers, clients and architects keeping project efficient and effective
- Drawing production management and working with digital files
- Close collaboration with BIM technologists who are responsible for models production
- Education and advanced training colleagues in specific software programs
- Monitoring that staff have access to the tools and equipment needed
- Oversight of procurement of the workstations so that hardware is efficient for the programs installed

- Producing content for the firm to use
- Keep staying on top of the last advancements in building technologies
- Hold and lead regular meetings to set project tasks and resolve issues
- Overseeing design budgets (Goconstruct.)

3.5.2 BIM coordinator

BIM coordinator is a key role in the BIM project. Coordinating the model (or part of it) he helps to establish and manage BIM project workflows and assisting in the effective resolution of issues that arise. (Professional Construction Strategies Group.)

Typically BIM coordinator duties may include:

- BIM protocols, BEP and other documentation development
- Ensuring compliance with protocols
- Data sets management
- BIM stakeholders coordination within their role in the BIM project
- Quality control procedures established to ensure the accuracy of models and databases
- Clash detection and avoidance
- Adopting BIM coordination programmes and progress reports
- Project team training and assistance explaining procedures and standards
- Sourcing and maintaining model content
- Where there are shared data and inter-model relationships, making sure these are recorded and monitored
- Data modelling and management coordination
- Keeping in touch with the design team and client
- Coordinating the handover of information at project milestones (Professional Construction Strategies Group.)

3.5.3 BIM modeller, engineer and draftsman

The BIM modeller creates the model and filling it with the required information. He follows special standards and guidelines to do that. BIM modeller models the elements and adds the required information to the elements. He can make new elements (custom Revit families for example). (Moreman 2015.)

BIM engineer creates and brings input to the model. The responsibility of the engineer is to bring special technical information inside the model. BIM draftsman annotating the views adding measures, dimensions, tags, legends, schedules, etc… (Moreman 2015.)

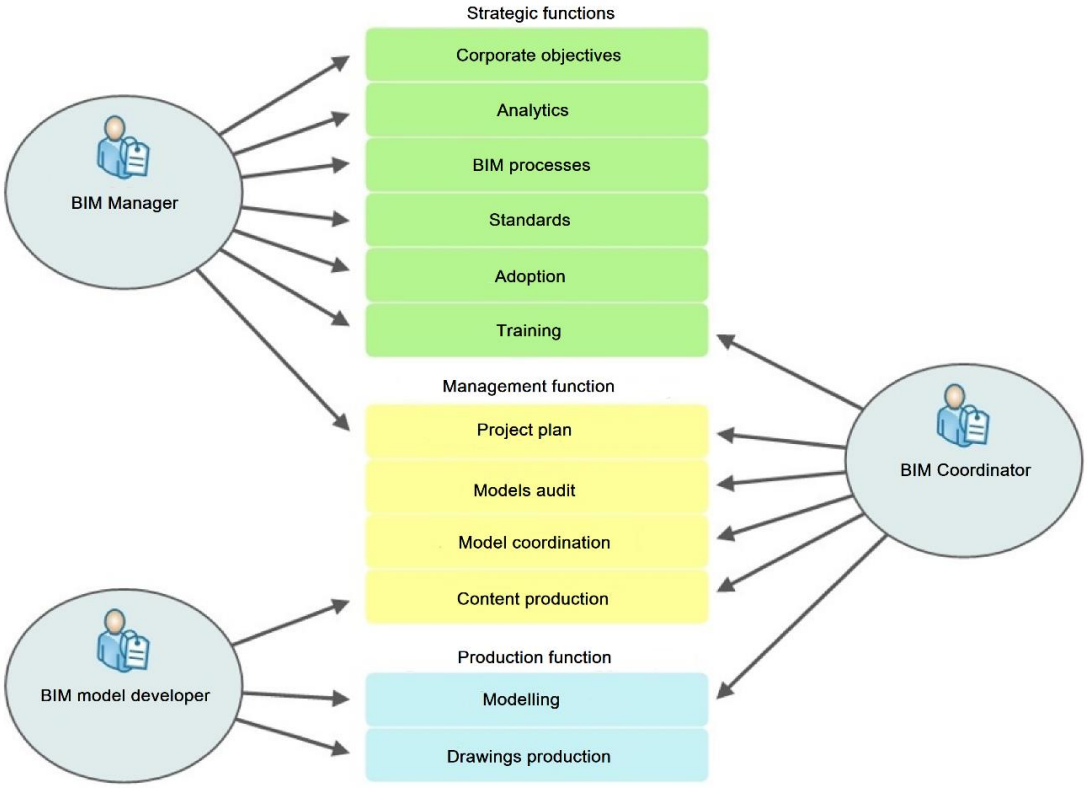

Figure 10. BIM roles and functions (Mekhoncev 2020) (adapted from Richard 2021)

The figure above shows how the project and company functions are shared among the BIM modellers, coordinators and manager.

3.6 BIM dimensions

The dimensions are different from BIM maturity levels. BIM dimensions are closely related to the available type of data. Different dimensions can be a part of BIM Level 2 and Level 3 as well. (Marketing ACO.)

Five types of BIM dimensions are as follows:

- 3D: Drawings that are taken from the 3D model.
- 4D: Time management and scheduling.
- 5D: Project cost estimation.
- 6D: Dimension that is linked to the lifecycle management of an asset.
- 7D: Facility management. (Marketing ACO.)

The figure below shows the key points of each dimension.

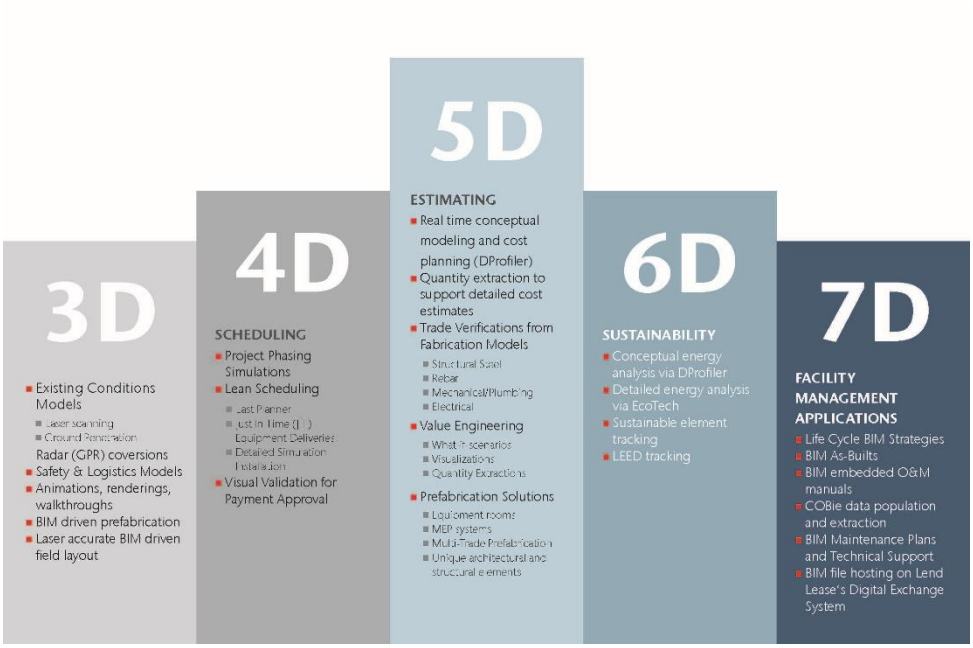

Figure 11. BIM dimensions (Marketing ACO.)

3.7 Software

BIM software allows to design and manage buildings/infrastructures on a model-based process, generating a digital performance facility`s functions and content. Also, BIM software can be used for CAD purposes not only across the architectural design.

List of BIM software (some of them):

- Autodesk Revit
- Autodesk Civil 3D
- Autodesk Navisworks
- Autodesk Infraworks
- Autodesk Advance Steel
- Autodesk Robot
- Graphisoft ArchiCAD
- Nemetschek Allplan
- Solibri
- SCIA Engineer
- Bentley Staad.PRO
- Bentley OpenBuildings Designer
- Bentley MicroStation

- Bentley SITEOPS
- Trimble Tekla
- Renga
- NanoCAD Engineering BIM
- NanoCAD Structure BIM
- Sapphire 3D
- AVEVA Bocad
- SketchUp
- MagiCAD
- Grasshopper
- Rhino
- Dlubal RFEM

3.8 Benefits of using BIM

In term of the construction industry that dates back thousands of years ago BIM is quite a new revolution technology on the market. This technology has a bigger impact even than computers and first CAD programs. BIM changes the industry and offers more and more benefits to engineering project members.

3.8.1 Benefits for architects

Architects become freer in choosing design options due to BIM especially computational design. Also, BIM analytical tools can be used to provide data-based design decisions. Among the information that the project can be filled with 3D modelling is a universal tool to create renders with impressive visualizations. 3D renders shows clients how their building will look in real life. That improves the communication between clients and architects making it more effective. (BIM Design Hub.)

BIM takes collaboration to a new level by using cloud services. Cloud collaboration tools create a common environment and let architects and project members work together in real-time giving each other the latest information. Using BIM tools helps architects to be sure that the project they are working on can be developed to a fabrication level. It creates an effect of unity and design continuity will be supported by other project members during the development process. (BIM Design Hub.)

3.8.2 Benefits for structural engineers

An informational model allows engineers to deal with competing design elements and parameters, hold viability testing and check structural integrity early during the design phase, make design changes and easy make corrections in structural models. (BIM Design Hub.)

BIM improves communication between structural engineers and project members. By reaching the continuous interaction of different engineers and different departments we get immensely shorten project timelines. Engineers can use point clouds and other reality capture tools to get more detailed information about existing structures, building and environmental features. (BIM Design Hub.)

3.8.3 Benefits for MEP engineers

Design calculation tools are integrated into BIM software and help MEP engineers to optimize systems and fabrication content to derive optimal layouts. BIM environment allows to develop of a detailed fabrication model from design intent and use it in shop drawings, procurement, ductwork manufacture, and installation. Collecting all design components in the information model improves collaboration and makes it easy. This is also a guarantee that up-to-date information will be available to every team member. (BIM Design Hub.)

3.8.4 Benefits for asset owner

Saving money during the design and construction phases of the project will be reached by reducing the time needed for design and construction. Improved team collaboration during the design phases and simplified data exchange with the contractor will positively affect on the amount of time needed to accomplish. The BIM model has an automatic system for cost estimation. The computer makes automatic calculations reaching a maximum level of accuracy and excluding possible mistakes that can happen during hand calculations. More accurate cost estimation impacts positively on the whole cost of the project. (Rybin, Ambaryan, Anosov, Gal'tsev & Fakhratov 2019, 98-105.)

Paper archive with all the building documentation becomes unnecessary. All the data needed for facility management is stored in the asset information model (AIM). Proper building information management ensures the safety of all the documentation and data about the project. (Rybin, Ambaryan, Anosov, Gal'tsev & Fakhratov 2019, 98-105.)

3.8.6 Other positive factors

All these factors will positively affect the project as a whole:

- reduction of construction costs by 30%
- project implementation time reduction by 50%
- construction time reduction by 10%
- designing time reduction by 20-50%
- coordination and alignment time reduction by 90%
- improving the project`s quality
- possibility to identify and solve collisions on all of the project phases
- reduction specifications calculation time
- wide range of standards and software allows choosing the right approach based on project characteristics (Rybin, Ambaryan, Anosov, Gal'tsev & Fakhratov 2019, 98-105.)

4 Open BIM

Building Information Modelling can be used differently within the construction industry. Open BIM is one way to use BIM that extends its functionality and effectiveness. This process enables the collaboration of different software within the same project called vendor-neutral it improves accessibility, management, usability and building digital data sustainability in the construction industry. Open BIM ensures constant information sharing and cooperation of all project members. (BuildingSMART.)

Open BIM transforms traditional peer-to-peer work process and improves project delivery and asset management by breaking data silos down. Adaption of the Open BIM approach allows a company to develop multi-party collaboration, efficient communication and industry-standard exchange methodologies. All these provide better project results, advanced predictability, improved performance and increased safety with risk reduction. Open BIM helps to connect people, processes and information during the whole lifecycle of an asset, which allows achieving asset delivery, operation and maintenance goals. Seamless digital workflows in addition to Open BIM make the most important project information available to participants on a timely basis supporting the decision-making process during various phases of the project from investment offer to demolition. Open BIM solves the problem of the traditional BIM process that is connected with different vendors data formats. (BuildingSMART.)

By using international standards, Open BIM extends the BIM abilities creating a simple common language. Open BIM technical applications remove disconnected workflows and improve data management. Open BIM operates digital workflows that use vendor-neutral formats such as IFC, BCF, COBie, CityGML, gbXML, etc. (BuildingSMART.)

Open BIM permits an accessible digital twin that creates a foundation for a long-term data management strategy for the building. With that, better sustainability and more efficient asset management can be achieved within the project. (BuildingSMART.)

Open BIM principles realize that:

- The key to digital transformation in the construction industry is an interoperability
- Interoperability requires open and neutral standards development
- Independent quality benchmarks is a core in data exchange
- Open and agile data formats enhance collaboration workflows
- Stakeholders can get value from the flexibility of choice of technology
- The flexibility of choice of technology creates more value to all stakeholders
- Long-term interoperable data standards guard the sustainability (BuildingSMART.)

Build asset industry benefits:

1. Open BIM improves collaboration for project delivery
2. Better asset management can be achieved
3. Open BIM makes the BIM data from the whole life cycle of the built asset accessible
4. Open BIM improves BIM by creating a common adjustment and language by adoption the international standards and work processes
5. Open BIM provides a common data environment that enables new workflows development, software applications and technology automation
6. Open BIM allows creating an accessible digital twin which forms the core foundation to a long-term data strategy for built assets (BuildingSMART.)

4.1 Vendor-neutral formats and software

Vendor-neutral formats and software are the core of Open BIM that enables unrestricted data exchange among project stakeholders.

4.1.1 Formats

The format is a language in that programs speak to each other. Here is a list of formats below that describes the key formats used in OpenBIM:

1. Industry Foundation Classes (IFC) is a standard digital description of the built asset, including civil infrastructure and buildings. (BuildingSMART.)

This is an open international standard (ISO 16739-1:2018), agnostic, vendor-neutral that can be used by most of hardware devices, interfaces and software platforms for different purposes and use cases. (BuildingSMART.)

To be more specific the IFC is a standardized data model that codifies:

a) Characteristics such as colour, material and thermal properties
b) Relationships (connections, locations, ownership, etc.)
c) Objects (slabs, beams, etc.)
d) Abstract conceptions (costing, performance, etc.)
e) Processes (operations, installations, etc.)
f) People (architects, owners, suppliers, contractors etc.) (BuildingSMART.)

This scheme describes how the facility of installation is utilized, built and operated. IFC defines physical parts of a built asset, MEP systems, abstract analysis models (structural,

energy), cost breakdown, work schedule, etc. The picture below shows a simplified description of IFC and what it delivers to the software. (BuildingSMART.)

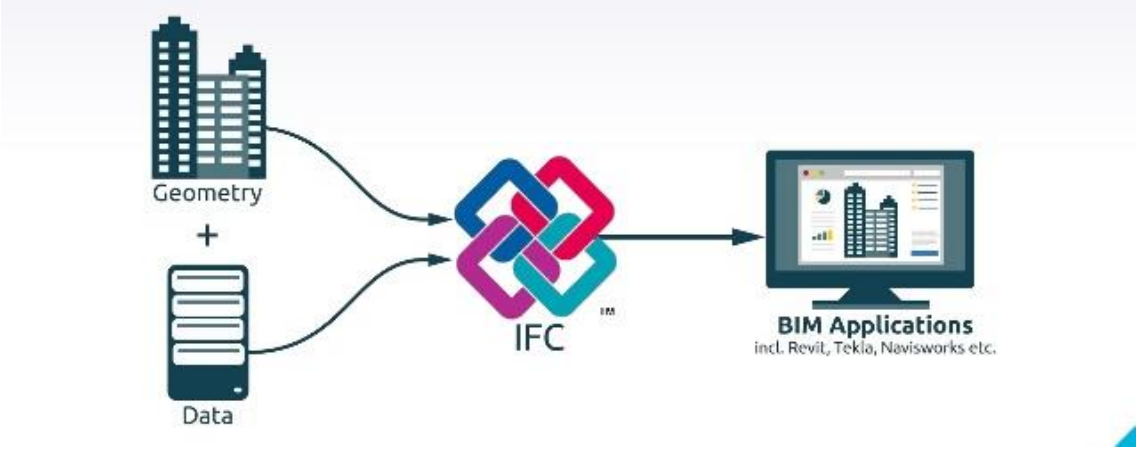

Figure 12. Industry Foundation Classes (Gamal 2019) (adapted from Richard 2021)

2. Information Delivery Manual (IDM).

The construction industry brings various companies and/or authorities together in a project. To work effectively, all participants have to know which and when different kind of information has to be used and exchanged. It is more important when we use digital tools because most of utilized tools across the industry have a low threshold of tolerance when it comes to the ability to interpret digital data. The ISO 29481-1:2010 has been developed by BuildingSMART to define a way to specify and capture information flow and processes throughout the whole lifecycle of the built asset. (BuildingSMART.)

3. BIM Collaboration Format (BCF).

This format allows different programs to exchange and work with models issues by using previously shared IFC models. It is possible to reached by using a file exchange between software platforms of using a RESTful service connecting software platforms directly or via BCF server being a hub for communications. (BuildingSMART.)

To be more specific BCF transfers XML data, which represents contextualized information about a problem directly referencing a view, captured via PNG and IFC coordinates, and elements of a BIM, as referenced via their IFC GUIDs, from one program to another. (BuildingSMART.)

Building Collaboration Format is a BuildingSMART International openBIM standard and free-to-use. There are two different ways to utilize BCF – via a file-based exchange or via a web service:

a) The file-based exchange workflow is simple and common to use. A BCF file (.bcfzip) is transferred from user to user, edited and returned. Unlike prescribed IFC file workflows, BCF files can be “roundtripped”, as long as everyone maintains the integrity of the shared BCF file and multiple copies of it are not circulated.
b) The web service-based (RESTful) API mode for BCF. This involves the implementation of a BCF server, with the option of also being the BIM server, that stores all the BCF data and enables project participants to sync the creation, editing, and management of BCF topics in one centralized location. (BuildingSMART.)

4. Model View Definition (MVD).

Generally, MVD is several ways to organize the overall IFC schema to describe a specific of workflow usage. MVDs can be as wide as the entire schema of as specific as some object types and associated data. (BuildingSMART.)

To improve BIM interoperability among different software applications the IFC schema is used to integrate a variety of different configurations and LODs. For instance, in BIM application a wall can be represented as:

a) Curve (or line) segment between two points
b) 3D geometry for analysis and visualization (extruded surfaces)
c) Simple form or/with specific construction detail (studs, pipe fitting, etc.)
d) Engineering properties (in addition to the data), scheduling, responsible party, cost information (BuildingSMART.)

IFC is not implemented in software due to the large scope since IFC is a big set of agreements; MVD uses IFC to define an exchange standard being used by software vendors. Since MVD is used by software vendors they become the basis against which software certification takes place. MVD is used to check software implementations to match the required criteria. (BuildingSMART.)

Here are two examples:

a) Architectural model is sent to the client to place within a larger urban context model that allows the client to use visualization of the design, in this case, an architect does not need to send all the modelling operations data (CSG) and object attributes but can share a simple geometry model with simple texture.

b) Precast manufacturers set requirements for the IFC data. They describe the use of assemblies, and that precise geometry is needed to be represented with BREPs. In addition to it, they define properties of precast elements. (BuildingSMART.)

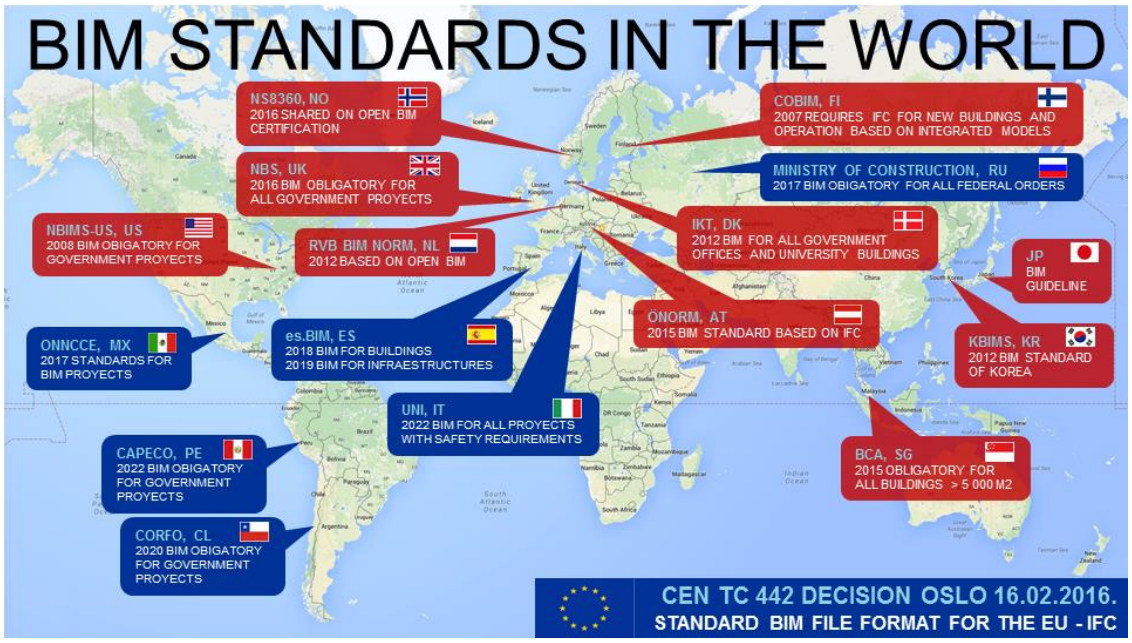

Figure 13. BIM standards in the world (OpenBIM)

Figure 13 is shown how and which year certain countries implement different standards.

4.1.2 Software

Some building design software that can work with IFC format and certified by BuildingSmart are listed below:

- Autodesk Revit
- Tekla Structures
- ArchiCAD
- BricsCAD
- MagiCAD
- AutoCAD
- Allplan (BuildingSMART.)

4.2 Open BIM workflow

The integration process of different design departments has become easier in recent decades. Especially in term of using 2D instruments - in this case, we can use Xref-links (references) that we put in CAD as a background image and coordinate/update/change manually. It means that the issue of interoperability becomes an issue of file compatibility between two applications. (OpenBIM.)

However, the usage of BIM in project delivery adds significant complexity to the process. In this case, simple BIM model transfer will not be enough because complex BIM elements are described differently in different programs and include not only general geometric descriptions. (OpenBIM.)

Interdisciplinary interaction between BIM solutions requires integration at the technological level, which enables the correct information transfer from one software to another and allows you to organize dynamic two-way communication. (OpenBIM.)

4.2.1 Step 1 – filtering elements

The BIM-based process of interdisciplinary collaboration starts with the sender. The first step is the preparation of the BIM model for export according to the client requirements and needs. Previous practice shoes that the recipient doesn`t need a full BIM model. Therefore, it is important to separate useful information by using different kinds of model filtering - turning off layers with unnecessary elements, turning off temporary structures, finishing materials. (OpenBIM.)

4.2.2 Step 2 – elements classification

Filtering ensures that the only required information will be sent. However, that is not enough. Often the recipient wants to get the correctly structured elements, which will be comfortable to work with. To solve that issue we need to manually set the elements class because different software vendors look at the model creating process differently. Here we can also to automate that process using the format that allows it. (OpenBIM.)

4.2.3 Step 3 – model export

After the classification process, we have a configured and prepared part of the complete BIM model that we need to send to the client. The required content depends on who is sharing the BIM model and what is the stage of interaction. (OpenBIM.)

In most cases, there is no need to transfer the entire BIM model constantly except the first steps in which the model is fully transferred to colleagues so that they can begin the process of BIM modelling faster. Also, there is no need to combine separate parts of the model into one to edit simultaneously. More often it is enough to use the model as a reference, something similar happens in real life when each specialist is responsible for his part of the project. In a conclusion: each specialist has to have an access to his data and control them in his BIM model. (OpenBIM.)

4.2.4 Step 4 – model coordination

As a result, each specialist unloads an information model from his project in an open format. After that the consolidation of models required in the same program to check the information model for collisions. As a result, each designer will receive assignments for changes in his project following a performed check. (OpenBIM.)

4.2.5 Conclusion

The open process of interdisciplinary collaboration is built on a few simple principles that can support almost any BIM solution with the active participation of the collaborating parties. The "openness" of the Open BIM methodology provides unique opportunities for all participants of the project. This is especially important when it comes to integrated project delivery (IPD). (OpenBIM.)

4.3 Open and closed BIM

One of the well-known benefits of BIM is the cost-saving by exchanging the data across different project members to estimate costs and timescales.

However, exchanging the data helps to achieve better results not all participants of the project use the same BIM application. Incompatible formats make the data exchange almost impossible. Open BIM resolves this issue making access for importing/exporting of data between BIM software programs easier. Closed BIM on the other hand standing for operating the same BIM software from one vendor among the project team including different disciplines. (GetBuldingWorks.)

The usage of Open BIM is very important for companies that work on large projects because large projects include different stakeholders from different firms that use different BIM applications. In this case, interoperability is the key. On the other hand, a single-family house developer may have an only in-house team where the same BIM application is used among designers, estimators, project and site managers and so on. (GetBuldingWorks.)

To let BIM applications "talk to each other" Open BIM protocols were developed and called IFC and Construction Operations Building Information Exchange (COBie). Although it shows good results in practice the interoperability problems are still very challenging. For instance data losses or elements of model not appearing correctly between different BIM software, which means risk. To begin with, it is important to gather and assign drawing objects for the rates data. For small projects, it is often disproportionate in the cost and complexity of the project. (GetBuldingWorks.)

4.4 Digital twins

A ”digital twin” is a built asset represented in digital form. This technology provides visual performance insights through continuous data inputs. Nowadays, it is the keyword in the construction industry. It has got a significant value in construction due to several reasons. Despite poor productivity and limited technological adoption, construction is a focus for disruption and change. For a long time organizations have had business models that offer a high level of risks. However, the situation is changing. There are some reasons why digital twins are the centre of attention and this can depend on the context that’s applied to deliver better outcomes. (BuildingSMART 2019.)

4.4.1 Digital twins in project delivery

BIM models today are a common thing among most of the projects of the construction industry. Ideally, the BIM model contains valuable asset information that can be used for a digital twin. However, the often-obscure file format used by engineers in early project phases can be the problem for digital twins to succeed. Nevertheless, fast advancement in new technologies and open-source workflow is making the situation better. For instance, reality capture technology is the easy way to transform reality into digital form with accurate and repeatable results. Drones and laser scanning equipment capture the site delivering precise, engineering-prepared digital models that can add information and some upgrades to existing BIM models. (BuildingSMART 2019.)

These models, also, require coordination to be serviceable and universal. Coordination is required to create a workflow that connects digital data or the data can become inaccessible. Digital ways of operation are developed by buildingSMART. Open standards form a platform for managing and exchanging digital data or workflows. IFC ensures the client that digital data of different project phases can accessed and used forever without any obscure data formats that become inaccessible later or just expire. An example of for project delivery using digital twins is in the following two projects. (BuildingSMART 2019.)

Aas-Jakobsen which won the 2018 buildingSMART Award for Design projects titled, Team_T, Avinor Airport, stated the IFC mandate as the reason for on-time and under budget project delivery. That was the client`s decision to push an Open BIM approach using IFC as an exchange standard allowing contractors to use the BIM applications they prefer to choose. It allowed us to achieve genuine interoperability among different project teams. The open approach also kept access to BIM data in a later phase of the project. Figure 14 shows the collected different IFC models into complex airport project. (BuildingSMART 2019.)

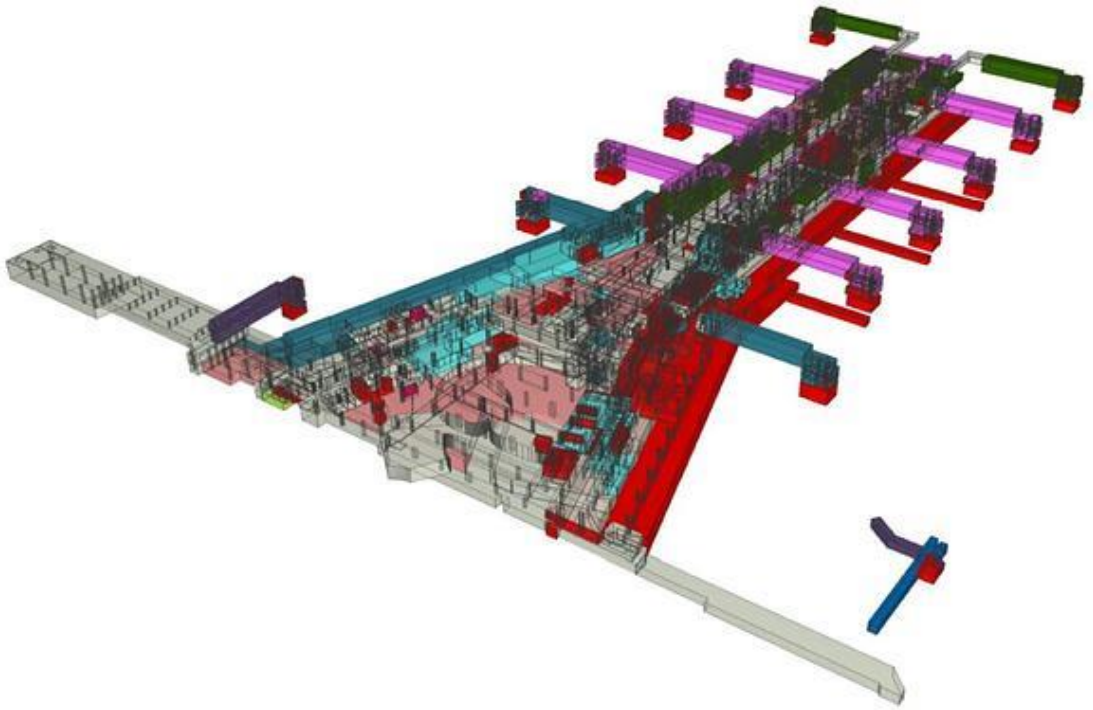

Figure 14. IFC generated data model of complex airport project (BuildingSMART 2019)

4.4.2 Digital twins in asset management

The most value the digital twins' technology can bring to asset management. Digital twins can be used to improve performance, integrity and asset reliability. In case of application of machine learning, AI and automation to digital twins then decisions about assets could soon become seamless. However, despite the attraction of technology, it is still a challenge. For instance, now, prganizations face a big challenge in managing change and synchronizing changes to apply advanced analytics for better decision-making. Most of this happens because digital data is often inaccessible and not adjusted for performance benefits. (BuildingSMART 2019.)

One example of benefits that digital twins deliver is the project by Minnucci Associati s.r.l. and their winning project from the 2018 buildingSMART Award category for Operators and

Maintenance. By utilizing a CDE (common data environment), the project was able to store more than 12,500 components and 44 digital models to create asset information models. These BIM models are connected to the existing work order management system to assist in the decision-making process during the Naples Station operation. The station has more than 400 trains in operation, also different spaces and shops, therefore assistance in facility running was critical. (BuildingSMART 2019.)

Figure 15. Naples station (Italy) model developed from laser scans (BuildingSMART 2019)

The picture above shows us the BIM model of Naples station in Italy that was developed mostly from point clouds and laser scans to assist with maintenance and operations of the station. The core of the project is the context to manage change. To remain effectiveness digital twin has to adapt and change. The real-time decision-making process via a digital twin needs plenty of data to be available in a BIM model. Open source platforms are available on GitHub for a trial period so users can add their expertise. This is an opportunity and real value-add for digital twins – the ability to adapt, change and maximize the potential of digital workflows for better decision making. Owner-operators can use it to improve lifecycle planning by making projects open and accessible. (BuildingSMART 2019.)

4.5 Internet of things (IoT)

IoT is a system of interlinked devices, mechanical and digital machines, objects, people or animals that staffed with unique identifiers (UIDs) and the ability to transfer data across a network without needing human-to-computer or human-to-human interaction. (Gillis)

A unit in the IoT can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver about the tire low-pressure or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and can transfer data over a network. Organization in a variety of industries use IoT to better understand customers to deliver improved customer service, operate more efficiently, improve the decision-making process and increase the value of the business. (Gillis)

The web-enabled smart devices that use embedded systems are the core of the IoT eco-system. These smart devices can be: processors, communication hardware and processors to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. (Gillis)

These devices also communicate with other related devices to process the information they get from one another. The devices mostly work without human intervention. However, they also need a setup, instructions or access to the data. The networking, connectivity and communication protocols used with there web-enabled devices largely depend on the specific IoT application deployed. IoT can also interact with artificial intelligence and machine learning to aid in making data collecting processes easier and more dynamic. Figure 16 is shown the example of an IoT system. (Gillis)

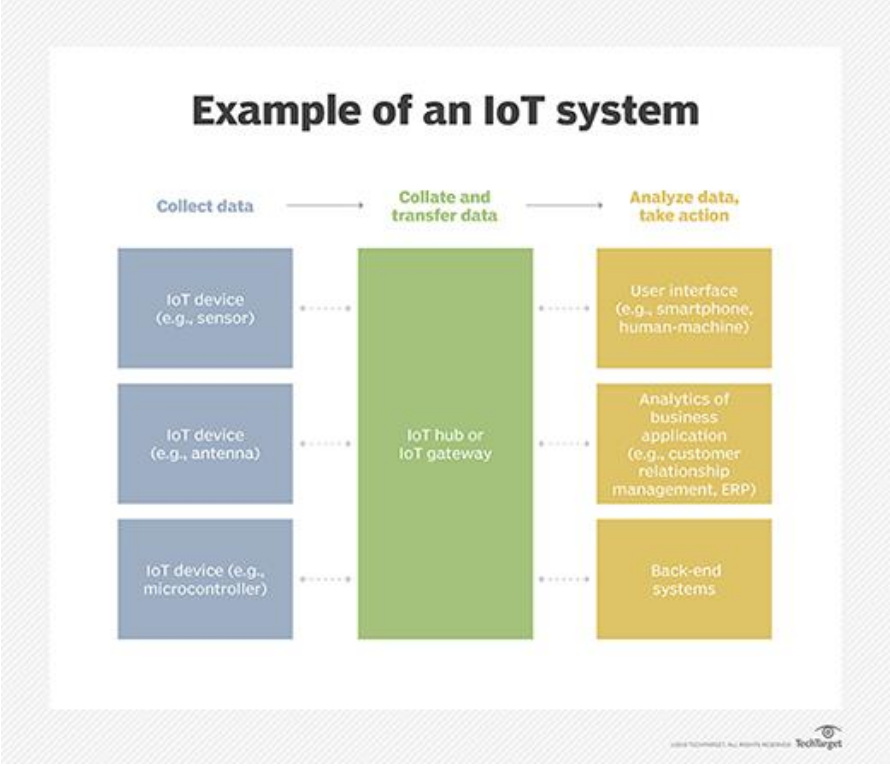

Figure 16. Example of IoT systems (Gillis)

4.5.1 IoT and Open BIM

New technologies such as wireless sensors, IoT, data processing and analysis and Building Information Modelling have a huge potential to change how we interact with the built environment and improve the experience for end-users and service providers. The IoT sensors are more and more used in the built environment and industrial applications. The number of connected devices is estimated to be 9 billion. The sensors are used in various application areas such as transportation, industrial, health and wellbeing, automotive and retail, building automation. The amount of sensor installations is increasing and some estimates suggested that there will be around 50 billion connected devices by 2020. (Dave, Buda, Nurminen & Främling 2018.)

As most of the IoT devices are installed within the built environment, the integration of the construction industry and IoT becomes a prime challenge. The built environment is taking a part in almost all aspects of human life, from education to healthcare and industries, where the field of BIM is expanding as a management and information delivery platform. BIM model is a part of every project phase within the lifecycle of the building. With the emergent popularity of the BIM platforms, there is an opportunity to leverage BIM so that it can be used to build open platforms and synchronise with diverse information sources such as building automation systems and wireless sensors. However, a gap in research in integrating built environment data with IoT standards that shows tangible open systems which are built upon open standards. The demand for open standards is increasing due to the plethora of protocols and information exchange standards being used in both the built environment and IoT domains. (Dave, Buda, Nurminen & Främling 2018.)

Moreover, the IoT domain is siloed with many researchers highlighting the need for cross-cutting applications built from a user-centric perspective. There is also a growing consensus that future "smart" applications should be more human-centric and support bottom-up innovation rather than being technology-centric and supporting top-down decision making. This research attempts to address this gap by providing the details of a proof of concept development that: a) integrates built environment and IoT data; b) provides tangible, intuitive and open user interfaces and c) is situated in the real-world rather than being lab-based. One of the motivations behind this study is to support distributed, cross-cutting and bottom-up innovation by supporting both consumptions of data provided by the system and development of applications and further research by utilising the APIs (Application Programming Interfaces) provided by the platform (Dave, Buda, Nurminen & Främling 2018.)

4.6 Open BIM in Finland

The BIM implementation process in Finland started in the 1990s. Today it`s development has led to government demands that all the government construction project leads (funded by the Finnish government) have to use BIM. Firstly, it was implemented as using IFC formats and following some national guidelines that gradually turned into Common BIM Requirements (COBIM). (Tapalov 2016.)

4.6.1 Common BIM requirements (COBIM)

Common BIM Requirement 2012 (COBIM) is a national guideline that is based on the BIM Requirements published by Senate Properties in 2007. This updating of national standards was funded by Senate properties as well as several other areas estate owners and developers, construction companies, software vendors and BuildingSMART (Finland). As a result of funding the updated Series 1-9 and new Series 10-13 were released in Finnish on March 27th 2012. (BuildingSMART.)

The structure of COBIM:

- Series 1: General part
- Series 2: Modeling of the starting situation
- Series 3: Architectural design
- Series 4: MEP design
- Series 5: Structural design
- Series 6: Quality assurance
- Series 7: Quantity take-off
- Series 8: Use of models for visualization
- Series 9: Use of models in MEP analyses
- Series 10: Energy analysis
- Series 11: Management of a BIM project
- Series 12: Use of models in facility management
- Series 13: Use of models in construction
- Series 14: Use of models in construction supervision (BuildingSMART.)

Additional materials (were published during 2016):

- Appendix1: COBIM2012 Supplementary appendix for the client of architectural design.

The guide contains instructions on the modelling method and accuracy of architectural plans for the design phase that serves procurement. (BuildingSMART.)

- Appendix2: COBIM2012 Supplementary appendix for the client of structural design

This guide contains instructions on the modelling method and accuracy of structural plans for the procurement design phase. (BuildingSMART.)

- Appendix3: COBIM2012 Supplementary appendix MEP quantity calculation guide.

The guide is intended to assist the customer in acquiring a BIM-based MEP design. With the help of the guide, the customer gets a uniform and comparable building technology material and quantity information for the use of different parties in the project. (BuildingSMART.)

- Appendix4: COBIM2012 Supplementary appendix Modeling requirements for MEP

The guide is intended to help architects, MEP engineers and structural designers produce compatible models. (BuildingSMART.)

It is worth to point out that in Finland the COBIM are considered not as a standard but as a recommendation of BIM usage and implementation. These requirements are aimed at achieving goals in new construction and renovation as well as during the building operation. Since COBIM is not a standard this document is "elastic" and can be changed and upgraded many times to meet upcoming trends and technology innovations in the construction industry. These requirements are minimal, but the ensure that BIM is performed within a certain binding design process that already guarantees the benefits of BIM. The figure below is the graphical representation of the Open BIM workflow. (Tapalov 2016.)

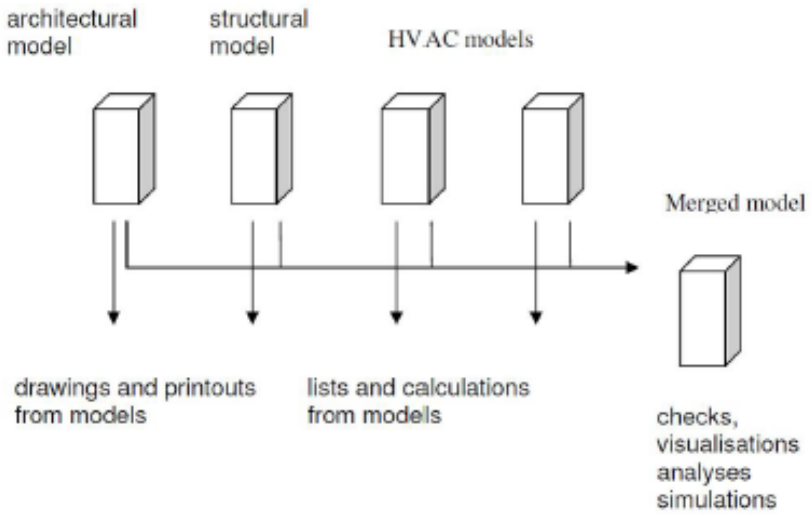

Figure 17. Open BIM workflow (Lehtoviita 2020.)

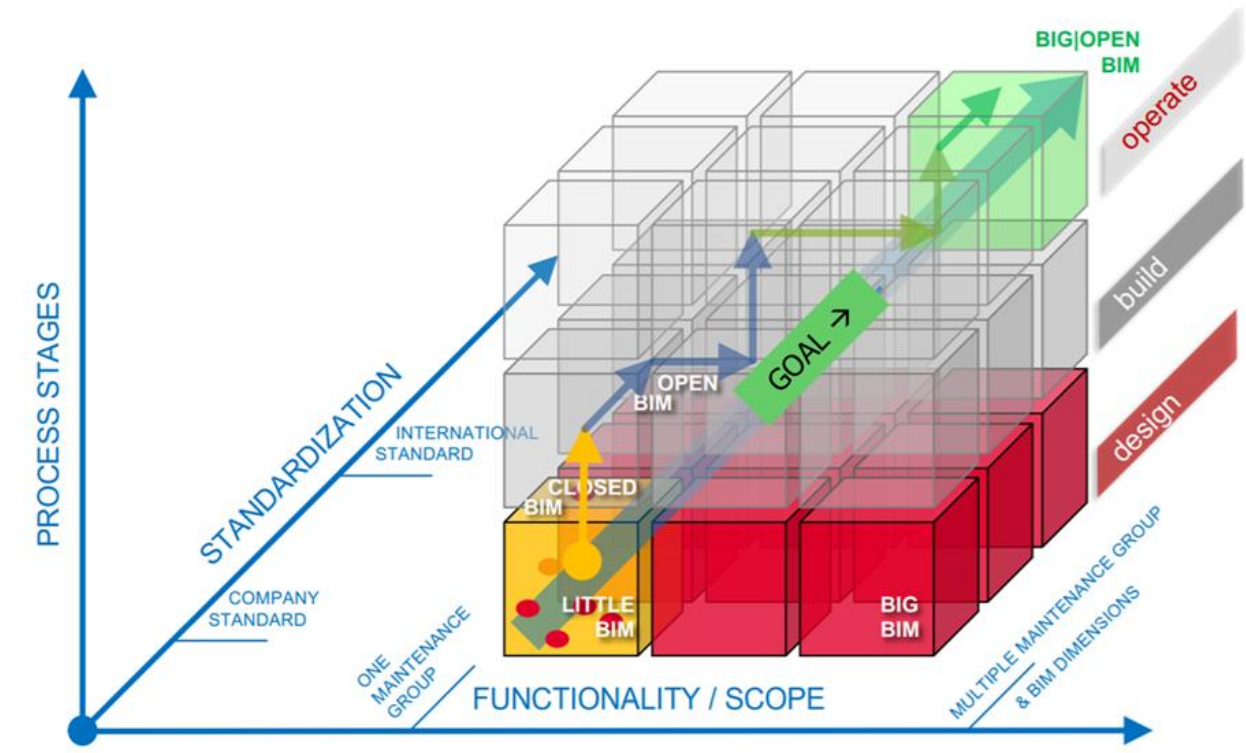

Figure 18. From “Little” BIM towards “Big” BIM (Perttula, Savolainen 2019)

Figure 18 shows the way of BIM development from closed format to Open BIM.

4.6.2 Common Infra BIM requirements

The Common InfraBIM Requirements cover the entire life cycle of an infrastructure project: initial material, different phases of design, construction, as-built documentation and, in the future, operation and maintenance as well. The modelling guidelines aim to guide, harmonise and improve the modelling practices in the entire infrastructure sector. The guidelines are based on the current best practices, and they will be updated regularly as the knowledge

and tools develop. In the Common InfraBIM Requirements, the requirement and guideline sections are highlighted to bring notice to their importance in the text. The requirement section presents the minimum requirements for modelling and the data content of models. It is considered that compliance with these specified minimum requirements is necessary for all infrastructure projects. The guideline section presents guiding practices that are recommended to be used in projects but are not absolute minimum requirements. (BuildingSMART.)

The Common InfraBIM Requirements YIV 2019 guidance package consists of the following chapters:

- Chapter 1. General
- Chapter 2. Initial data material
- Chapter 3. Design
- Chapter 4. Construction
- Chapter 5. Maintenance (will be updated later) (BuildingSMART.)

Chapter 1 “General” is a general introduction to the approach for infrastructure projects that utilise modelling. The first chapter describes the fundamentals and basic concepts of the modelling to ben carried out in the projects, as well as the general requirements and instructions concerning the production and utilisation of the models in different project phases. More detailed requirements and instructions are presented in Chapters 2–5. At a minimum, each party of the project must familiarise themselves with the general section, in addition to the requirements relevant to their contribution. The person responsible for managing the project or its information management must master the principles of modelling requirements as a whole. For this new guidance package version, efforts have been made to clarify and unify the structure of the texts to make the text more readable. Infrastructure project’s project phases as well as the quality assurance, cost and quantity calculation and visualisation of each phase are presented in connection with each chapter, not as separate sections as in the Common InfraBIM Requirements YIV 2015. (BuildingSMART.)

4.6.3 Infra model data exchange

Infra model is a way to exchange infrastructure information. The core of this method is open LandXML-standard. The initial version is Infra model, which consists of subsoil surfaces, parts of terrain models, road and rail geometries and construction layers. It also covers water supply and sewage and some facilities. The Finnish method of using LandXML is explained in Infra model documentation. This model does not gather all the elements in

LandXML. Although, some Infra model specific extensions have been added. The most important element is the Infra classification system. (BuildingSMART.)

Since May 1st 2014 Infra model is the exchange format required by the Finnish Traffic Agency and major cities. (BuildingSMART.)

4.6.4 Standards

The following standards are used by Finland. Some of the standards are used in many other countries within the BIM implementation strategy:

- Industry Foundation Classes (IFC)
- Data Dictionary (DD) (BuildingSMART.)

Data Dictionary is an international terminology, which is a foundation to create and maintain open platform BIM elements. Also, it helps to define multilingual product libraries that can be utilized by BIM software. Data Dictionary was previously called IFC Library. (BuildingSMART.)

- Information Delivery Manual (IDM)
- Model View Definition (MVD)
- Building Collaboration Format (BCF) (BuildingSMART.)

4.6.5 Combined house + infa + city model

Infrastructure and area planning projects are geographically large and have massive amounts of data. xD Twin is a combination of BIM and GIS with the world's leading Web3D streaming technology. xD Twin allows managing unlimited size datasets with instant model loading, also with mobile devices. (Lehtoviita 2020.)

This technology allows: Import of common 3D and BIM formats including IFC and LandXML, integration with city models, sketch your ideas in 3D, schedule in 4D, measure, clip, collaborate, present and publish your models to citizens or view on-site with GPS and AR. Figure 18 is shown what forms the xD twin. (Lehtoviita 2020.)

4.6.6 Future perspectives of Open BIM in Finland

The systematic infrastructure standardisation work in Finland (Inframodel, YIV) has not gone unnoticed in the international arena. Finnish experts and organisations are closely involved in the operations of Infra Room and Rail Room (the Rooms are development units of BuildingSMART International that are open for everyone). Figures known from Finnish

standardisation specifications can be seen, for example, in the IFC Road reports. Finnish long-term national standardisation work is gaining new momentum as digitalisation has raised its head as a major driver of society, and international standardisation has led to a more widespread interest in the subject. As shown in Figure 19, the Bowling Alley is beginning to turn into a preliminary Tornado. (Perttula & Savolainen 2019.)

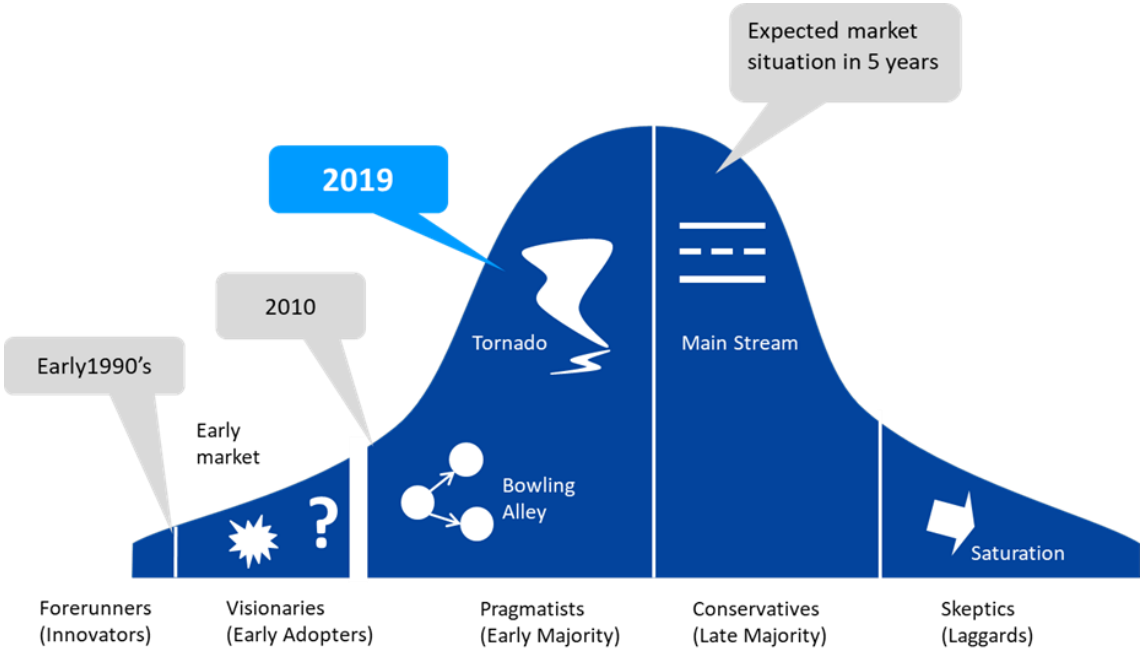

Figure 19. Future perspectives of Open BIM (Perttula & Savolainen 2019)

What will the future bring? There is a strong belief that the BIM Tornado will come. The benefits will be more easily found in new projects, as technology and knowledge inevitably evolve. Everyone should now be vigilant in this development. If you or your organisation are interested in Finnish or international activities concerning BIM, then contact to BuildingSMART. International standards are here to stay, and free to use. (Perttula & Savolainen 2019.)

5 BIM workflow and technologies in Russia

The research was carried out within the project «BIM-ICE - Integration of BIM into higher and professional education».

Form of research was expert survey. Two online questionnaires were available: for heads of organizations and for the organizations' specialists. The survey was conducted from July 6 to September 15, 2020. (BIM-ICE project. 2020.)

The goal of the research is to analyze existing practices of BIM application, its advantages and difficulties, as well as possibilities of cooperation of educational organizations and business structures in promotion of BIM-competences.

The surveys were developed during the multiple videoconferences with BIM-ICE personnel and structures of the surveys were fully changed several times. The final version of the survey was send to responders in 6th of July 2020.

5.1 Heads of organizations survey

5.1.1 List of responders

19 representatives of the following organizations participated in the survey (spelling and punctuation of respondents retained):

1) JSC Stroyprojekt Institute (2 responders)
2) LLC «Tekhno-Nikol Construction Systems»
3) SIGNI
4) Sibzheldorprojekt
5) AO NPO PI «OGP»
6) JSC «LENNIIPROJEKT»
7) PMU «Lengiproinzhprojekt»
8) JSC «N-Systems»
9) LLC «S-Info»
10) PIK-Projekt
11) GC PIK
12) YIT Saint-Petersburg
13) JSC «PIiNII VT «Lenaeroprojekt»
14) IE Korolev Viktor Sergeevich
15) LLC «FERRUMPROM»
16) LLC «Project office – GS»

17) Bonava
18) JSC «MegaMade»

The majority of responders indicated St. Petersburg as the city/region of their activities (13 respondents, or 68 per cent), Mr. Moscow (10 per cent), Mr. Novosibirsk and Mr. Orenburg each. Two other responders identified their region of activity as Russia (10 per cent).

Most of responders chose ST. Petersburg as the region of their activities – 13 responders (68%), 2 from Moscow (10%), 1 from Novosibirsk and 1 from Orenburg. Two more responders chose their region of activity as Russia.

Scope of organizations activities (multiple choice):

1) developer – 2 (10%)
2) Investor – 1 (5%)
3) client – 1 (5%)
4) general contractor – 2 (10%)
5) developer– 1 (5%)
6) architectural design – 7 (37%)
7) design – 16 (85%)
8) facilities management – 0 (0%)

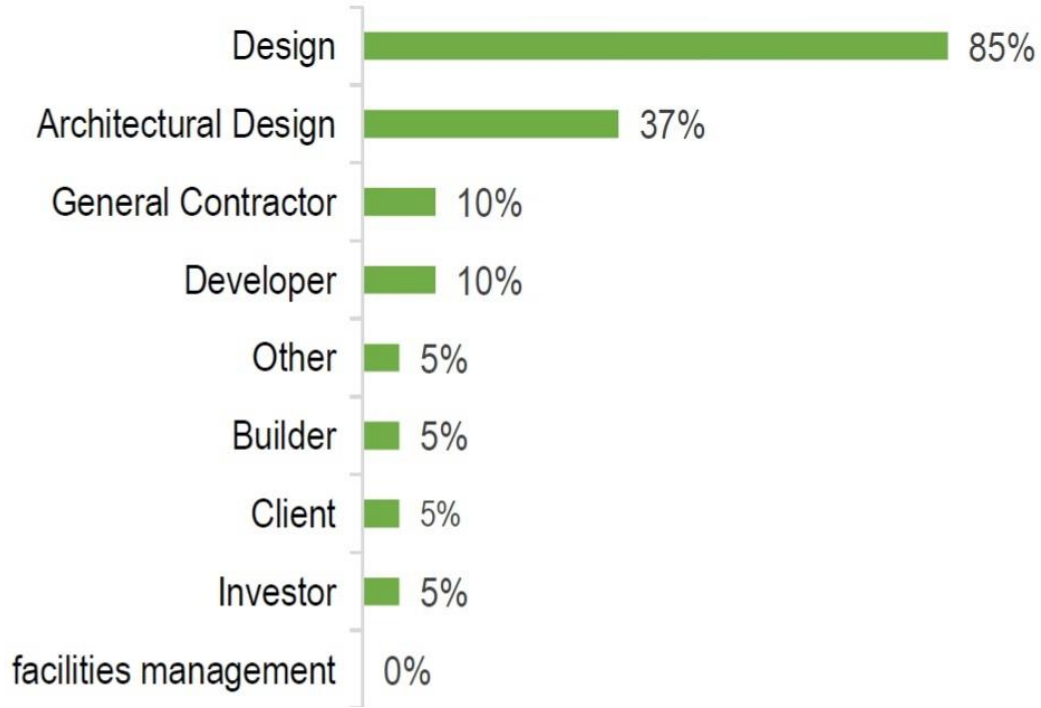

Figure 20. Scope of organization activities

Responders options:

Building materials manufacturing – 1 (5%)

Most of representatives of organization working in Saint-Petersburg in the field of architectural and structural design. The results of the survey mostly reflect the situation of BIM implementation among the design companies in Saint-Petersburg.

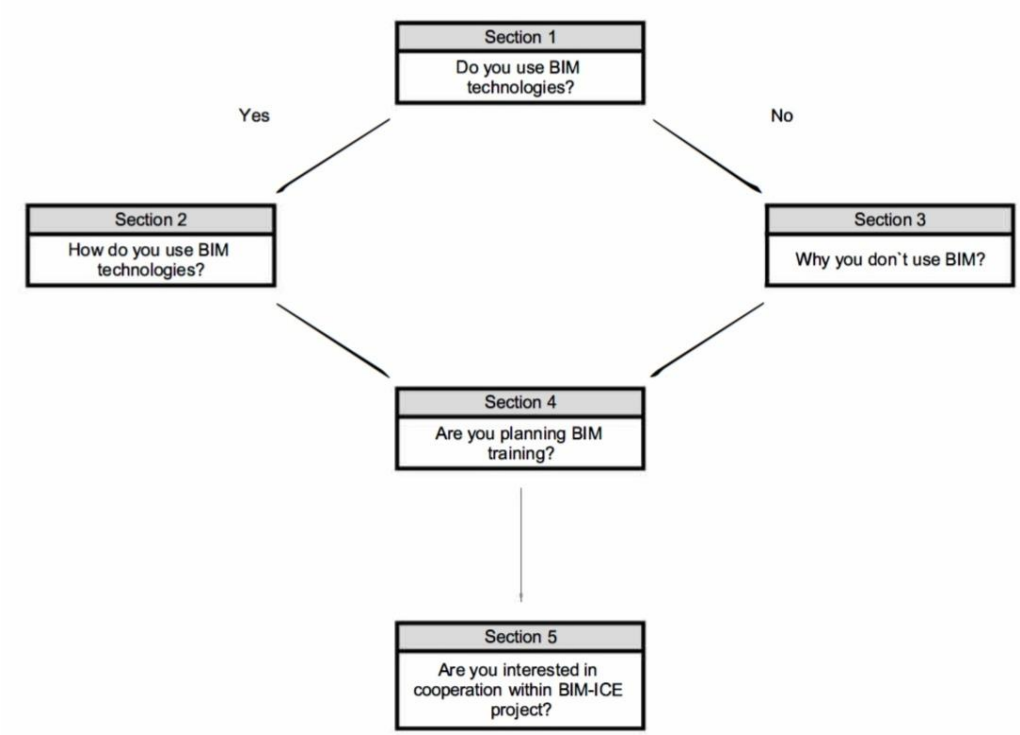

Figure 21. Heads of organizations questionnaire map

The figure above shows the principal structure of heads of organizations survey.

5.1.2 Main survey questions and answers

1. Do you use BIM technologies in your work?

1) Yes in each project – 8 (42%)
2) Yes, not in every project – 9 (48%)
3) No– 2 (10%)

Two responders answered that they don`t use BIM technologies. They were asked with following question:

1.1. What is the reason for your organization not to use BIM technologies? (multiple choice)

1) Current amount of project does not allow to implement new technologies, work of organizations is effective enough without BIM– 1 (50%)
2) Lack of normative regulations– 0
3) Weak regulatory environment – 0
4) Lack of qualified and competent specialists– 0
5) Employees resist the innovations implementation– 0
6) High implementation cost– 2 (100%)
7) Threat of sanctions on imported software – 0

Both respondents picked the high implementation cost as a common reason of not using BIM. One of respondents answer that it`s organization is effective enough without using BIM. Also both of them on the question about planned BIM implementation and training (7th question) answered that BIM implementation and training are not planned.

17 responders answered on the next block of questions:

2. What are the reasons of BIM implementation on your organization? (multiple choice)

1) Clients demands – 5 (29%)
2) Project quality improvement – 13 (76%)
3) Improving competitiveness – 14 (82%)
4) Reduction in cost and time, improving profitability – 7 (41%)
5) Changes in law and demands of regulatory environment – 3 (17%)
6) Increase in amount of requests on BIM-based projects – 9 (52%)

Figure 22. Reasons of BIM implementation

Responders options:

- We are client and use all the advantages where it can be essential, in sales, design and construction

Responders indicated that the reasons for introducing BIM were complex, with only four responders choosing for one reason. As a rule, 3-4 reasons were selected (8 respondents), 1 responder chose all 6 reasons suggested.

The most common combinations of options are:

- Improved performance and competitiveness - 11 respondents;
- Increased competitiveness and reduced costs and lead times, increased profitability - 6 respondents.

3. Who initiated BIM implementation?

1) Owner – 2 (13%)
2) Company managers – 12 (75%)
3) Strategy planning unit – 1 (6%)
4) Design unit – 0
5) Construction unit – 0
6) Single employees having BIM competences – 1 (6%)

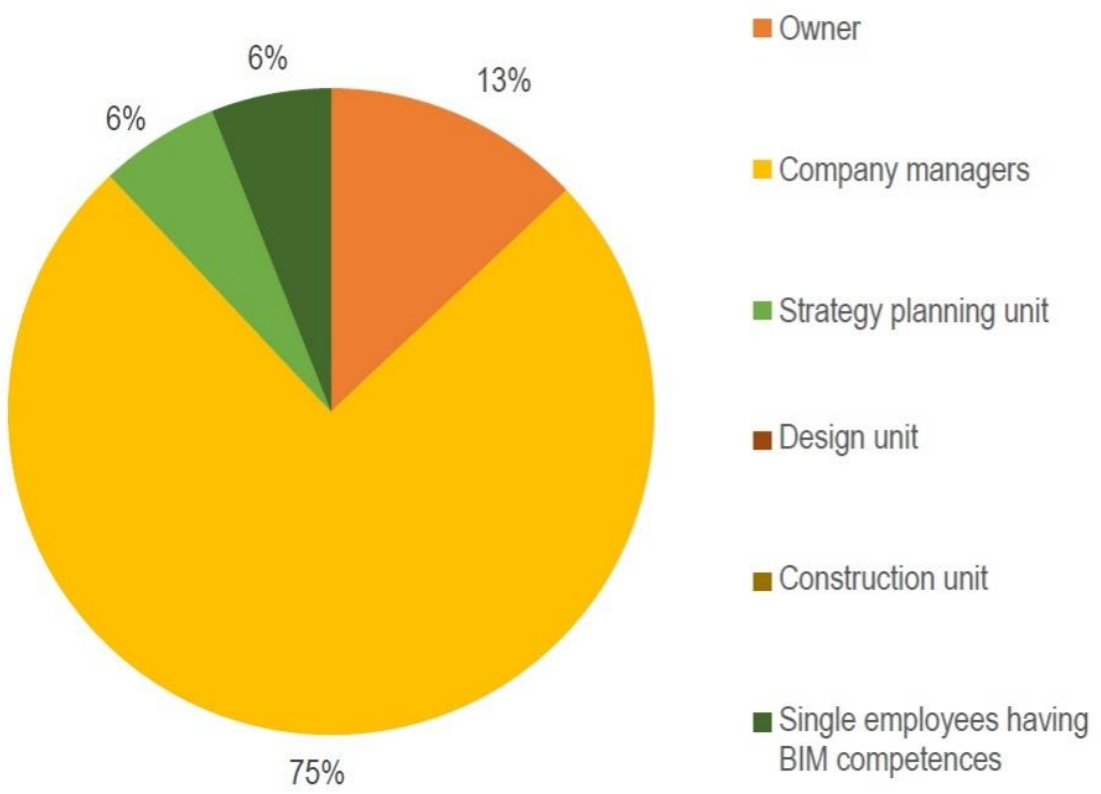

Figure 23. BIM implementation initiative

In most cases the introduction of BIM was related to the initiative of the company's management, the owners of only two organizations initiated the introduction of technologies, the average management and specialists also in two cases initiated the introduction of BIM.

Thus, top management is the main influence group for the introduction of BIM, in most cases (82%) the initiative came from the top, respectively, to make a decision on the introduction of new technologies the management of the company motivation needed.

4. Advantages that BIM implementation provides: (multiple choice)

1) Accessibility of information for all the project participants, rapid information and data exchange – 13 (76%)
2) Understanding the scope of the project among all the project members – 14 (82%)
3) 3D and 4D project visualization – 13 (76%)
4) Design time reduction – 5 (29%)
5) Cost reduction – 4 (23%)

6) Project quality improvement – 13 (76%)
7) Increase in income and profitability – 4 (23%)
8) Rational and efficient use of resources – 4 (23%)

Responders option:

- Competitive advantage
- Visualizations, materials for sales and marketing, product improvement
- Budget estimation, purchase

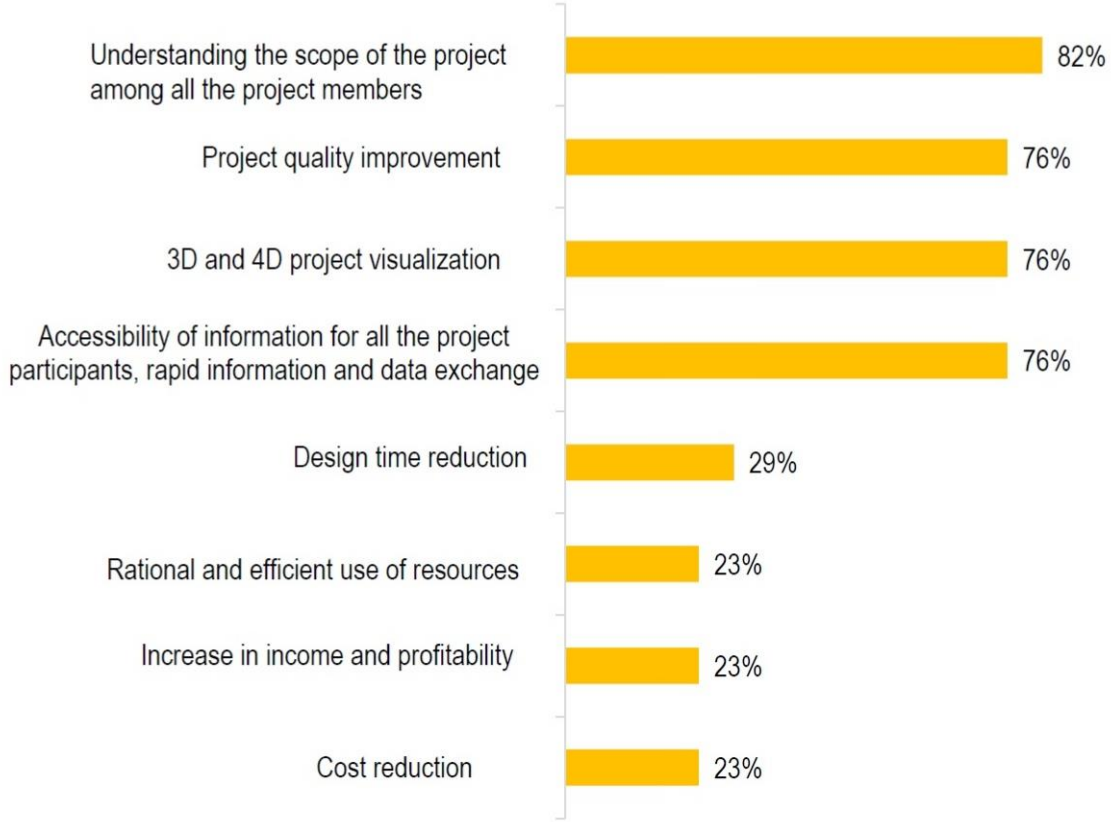

Figure 24. BIM advantages

The majority of responders (58%) indicated a large number of benefits from using BIM: 11 selected 4 or more benefits, of which 5 selected all the benefits offered, all of which were from organizations, in which BIM is used in all projects.

5. Difficulties in using BIM technologies: (multiple choice)

1) Resistance to change and innovations among employees – 6 (35%)
2) Lack of a system of State standards for the implementation of BIM-based projects – 7 (41%)
3) Weak regulatory environment – 7 (41%)

4) Lack of qualified employees, BIM managers in organization – 10 (59%)
5) Lack of domestic software and data bases, impossibility of complete import substitution – 9 (53%)
6) Lack of necessary interaction between different sections of the project – 1 (4%)
7) Differences in designing time among different project stages – 3 (17%)
8) Project expertise – 1 (6%)

Responders option:

- Complexity in interaction with different project organizations, different standards, software, etc.
- Non-conformity with the composition and content of the design stages according to the normative requirements of the Russian Federation and the requirements of the customer in context of BIM design
- Absence of increasing coefficients for the project implemented in BIM
- We have non-critical difficulties

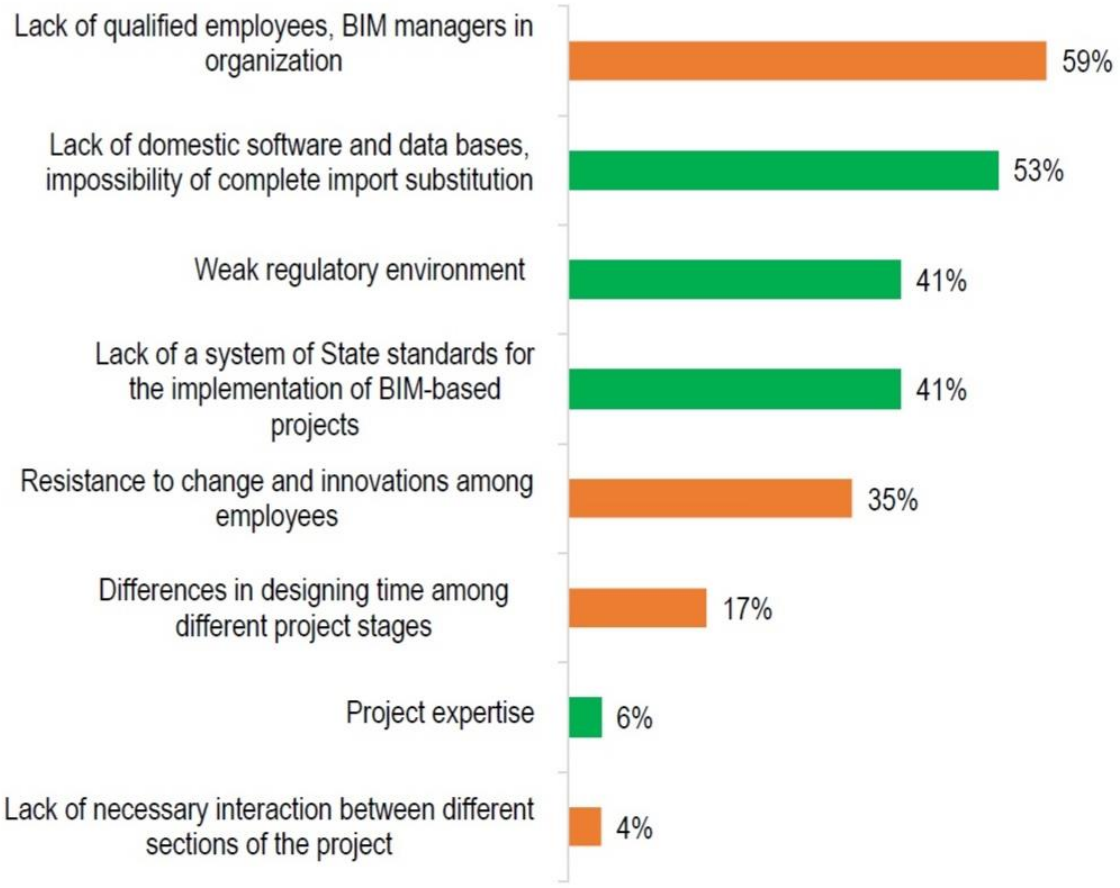

Figure 25. BIM usage difficulties

All apart one of the responder report difficulties with the implementation of BIM technologies. Among the suggested responses, the difficulties are internal, organizational (1, 4, 6.7, indicated in the figure in orange) and external (2, 3, 5, 8, indicated in the figure in green).

The main internal problem is the lack of the necessary competencies among staff in the organization (which is relevant for 59% of the respondents), and the main external problem is the insufficiency of domestic software and databases (53%). External difficulties were important for a slightly larger number of responders.

6. Compare the expectations of BIM implementation with it`s real effect on a scale of 0 to 5:

- 0 – It is hard to answer – 0
- 1 – results are absolutely mismatch expectations – 0
- 2 – real effect mostly mismatch expectations – 1 (6%)
- 3 – results more match expectations than not – 9 (53%)
- 4 – gained effect completely match the expectations – 6 (35%)
- 5 – real effect exceeds expectations many times over– 1 (6%)

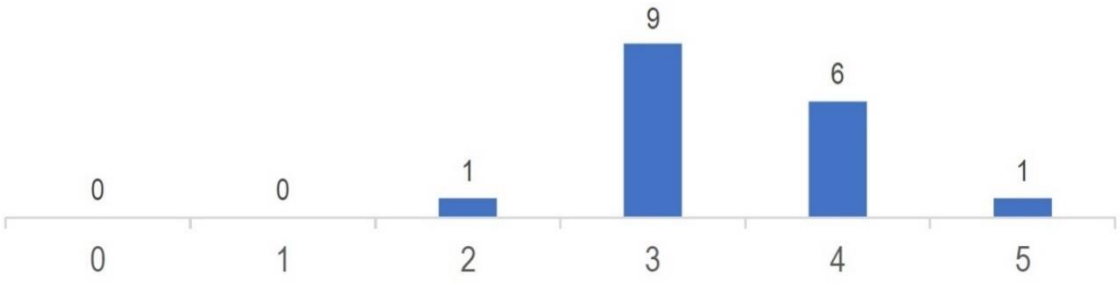

Figure 26. BIM implementation effect

Average – 3,4

It should also be noted that there is a link between the following: organizations with BIM in all projects have higher levels of satisfaction with the introduction of BIM (GPA 3.75 compared to an average of 3.1 for organizations where BIM is not used in all projects).

All the responders answered the following block of questions:

7. Does your organization plan BIM trainings and how will it be organized?

1) Yes, by our own – 11 (58%)
2) Yes, with the help of corporate universities or with outside expertise – 4 (21%)

3) Yes with help of multiple training programmes on collaboration with educational organizations – 1 (5%)
4) No, we hire employees that already qualified in BIM – 1 (5%)
5) Not planned – 2 (11%)
6) It is hard to answer – 0

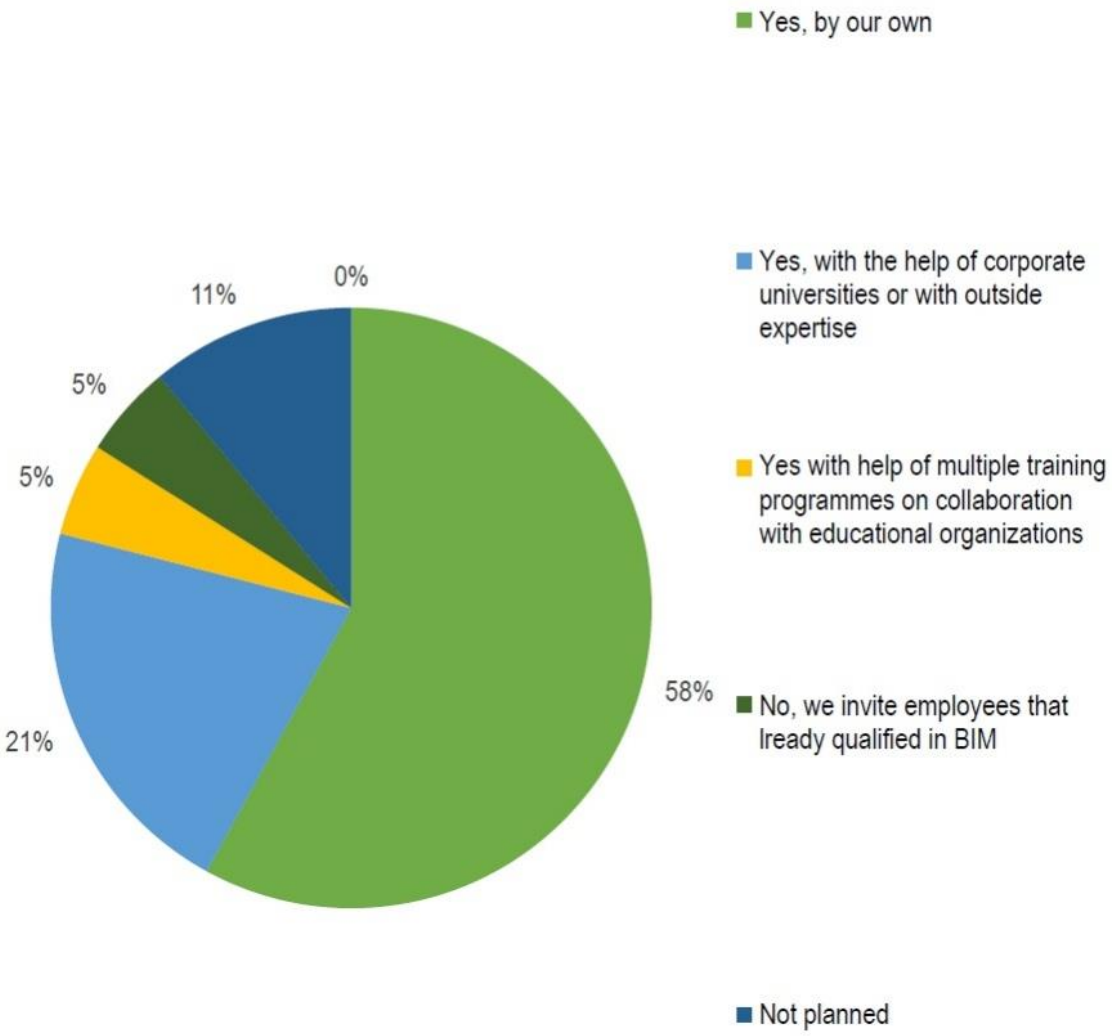

Figure 27. BIM trainings planning

As noted above, two respondents in organizations that do not use BIM were the only ones that do not plan to train staff, while in another organization staff with the required competencies are being recruited.

The most of respondents (84%) plan to train their staff. However, mainly by their own efforts (58%), 7 of them (36%) also identified among the difficulties a shortage of competent staff, therefore training of staff for these organizations is one way of overcoming the existing difficulties.

It should be noted that all organizations where BIM is used in all but one project plan learning in-house, it means that organizations with widespread use of BIM, suppose that they have sufficient competence for training.

All organizations that do not use BIM in all but one project also plan training - 4 (21%) of them in-house, 4 (21%) at corporate or external universities, 1 (5%) further training and supplementary education programmes.

8. Which way of collaboration with educational institutes you would prefer? (multiple choice)

1) Guest/open lectures and seminars – 11 (58%)
2) Teaching through study sessions, electives – 3 (15%)
3) Organization of BIM Championships, Olympiads, etc. in BIM – 3 (15%)
4) Participation in BIM Olympiad Championships, etc. in BIM as experts – 5 (26%)
5) Mentoring through internships and apprenticeships – 9 (47%)
6) Including of students in the organization’s project teams – 8 (42%)
7) Providing of software and training in its use – 4 (21%)

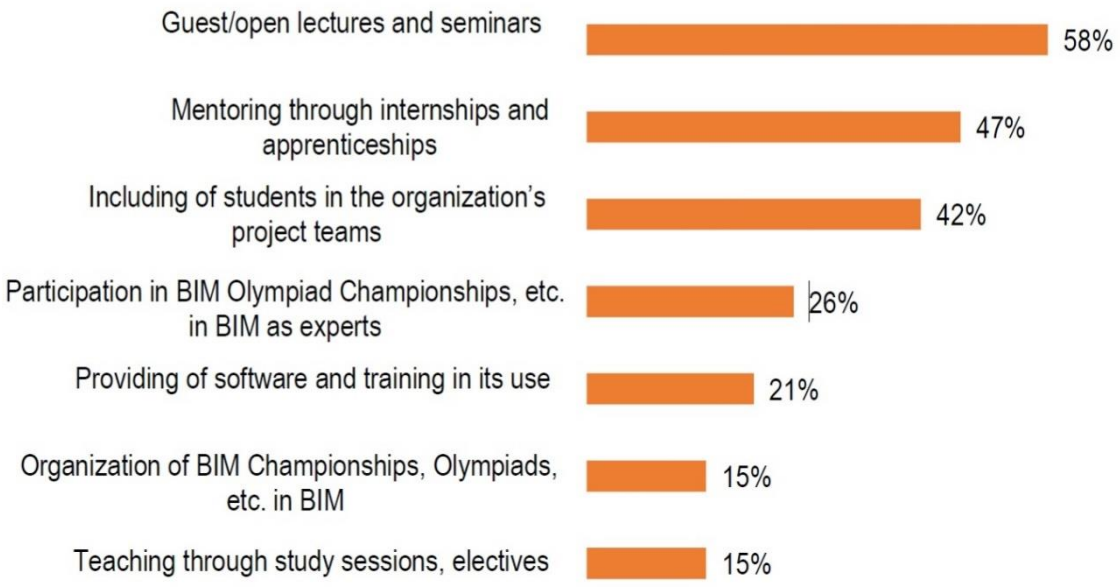

Figure 28. Collaboration with educational institutes

All but one of the organizations (the respondent answered the question "not yet determined") indicated possible forms of cooperation with educational organizations. Four organizations, however, are most open to cooperation in different formats (having selected four or more options).

Among the respondents considering 1-2 forms of cooperation, the most popular were "guest/open lectures and seminars"; "mentoring through student internships", the most traditional forms of cooperation, which are rather episodic.

5.2 Employees survey

5.2.1 List of responders

122 responders from 94 organizations have participated in the survey:

1) LLC Prorab
2) «Kraftovy remont»
3) LLC «MM-Technologies»
4) LLC «GCMK»
5) JSC «Trest № 68» – 4 responders
6) Spb GSC «FKSR»
7) Vniig
8) LLC «Portal Plus»
9) LLC «SpecStrouProjekt»
10) LenOblRestavracia
11) LLC «AVK Grupp»
12) LLC TEP Spb – 5 responders
13) LLC «GC Story-Expert»
14) LLC «MRGT»
15) SCF Micromax
16) InzhStroyCapital
17) LLC «FERRUMPROM»
18) JSC «Admoralteiskie verfi» - 2 responders
19) LLC InzhTechProm
20) Spectrest №27-2
21) JSC «Service-Nedvizhimost»
22) CJSC VAD
23) MonskProjekt
24) LLC ‘MaxVent’ – 2 responders
25) LLC «PCB «ZhilStroy»
26) JSC «VAD»
27) LLC «Eurogazproekt Spb»
28) JSC «Lengiprotrans»

29) LLC REHAU
30) LLC JUPITER
31) LLC «VoterPriceInvest»
32) LLC «PSG»
33) JSC ATOMPROJEKT – 2 responders
34) LLC «TD Elita» – 2 responders
35) Georesurs
36) LLC «Baltkotlomash»
37) LLC ПСК «Uraldomstroy»
38) LLC «Projektnoe buro GS»
39) JSC «Petersburd Dorservice»
40) LLC «Spectrum»
41) Renaissance Construction – 5 responders
42) JSC «Lenmorniiprojekt»
43) LLC «Severnaja kompanija»
44) LLC «VEKA Rus» - 2 responders
45) LLC «Rumpu projekt»
46) Nndevelopment
47) LLC «Integracija»
48) JSC «LENNIIPROJEKT»
49) ROSECO
50) ITEM
51) BIM Academy
52) LLC «Intellektualny Stroitelny Inzhiniring»
53) LLC «EuroKhim Project» – 2 responders
54) JSC «Lenpromtransprojekt»
55) Projektny Institute №1
56) JSC N-Systems
57) LLC «Stroupanel»
58) Bonava
59) JSC KAPSTROYPROJEKT
60) TAFE RESERV
61) IC Stroyexpert
62) YIT Saint-Petersburg
63) LLC Metropolis
64) JSC «Signi Grupp»
65) Atlant

66) A-Graph
67) LLC «PIK-Projekt»
68) lenspecsmu
69) Architectural firm «Skorikov Architects»
70) Z&K
71) AFRY
72) LLC «CEIPSK»
73) LLC pillar
74) Gazprom Neft Alternative fuel
75) Project Office - GS
76) Development Systems – 2 responders
77) JSC «MegaMade»
78) LLC «NPO «ANTARES Trade»
79) CJSC Geostroy
80) PCC Energoprojekt
81) Titan2
82) JSC branch «SEP» – 2 responders
83) LLC NFP Retro
84) LLC «NVK-Holding»
85) Prostor L Plus – 2 responders
86) LLC «NovTechProjekt» - 2 responders
87) LLC «LSR Nedvizhimost»
88) LLC «Region»
89) LLC «Elite»
90) SPbGASU
91) LSR Grupp
92) LLC AQUANORD– 2 responders
93) JSC «Institut «Stroyprojekt»
94) LLC AMC-Projekt

4 responders did not write the name of their organization

Most of responders, 98 – 80%, chose Saint-Petersburg as a region they work in. The remaining responders indicated the following regions and cities of their activities:

- Leningrad oblast– 6 (5%)
- Moscow– 6 (5%)
- Russia – 3 (2,5%)

- Mir – 3 (2,5%)
- Northwestern Federal District – 3 (2,5%)
- Izhevsk – 1 (0,8%)
- Uhta – 1 (0,8%)
- Yekaterinburg – 1 (0,8%)
- Vantaa – 1 (0,8%)
- Vologda region – 1 (0,8%)
- Minsk – 1 (0,8%)
- Republic of Crimea – 1 (0,8%)

Scope of organizations activities (multiple choice):

1) Developer– 11 (9%)
2) Investor – 3 (2,5%)
3) Client – 10 (8%)
4) General constractor – 35 (28%)
5) Builder – 22 (18%)
6) Architectural design – 38 (31%)
7) Design – 85 (70%)
8) Facilities management – 13 (10%)

Responders options:

- Object repair – 1 (0,8%)
- Mathematical modelling – 1 (0,8%)
- Examination of buildings and structures – 3 (2,5%)
- Shipbuilding– 2 (1,5%)
- Contractor– 2 (1,5%)
- Engineering systems provider – 1 (0,8%)
- Oil and gas – 1(0,8%)
- Main heat networks – 5 (4%)
- EPC - contractor – 1 (0,8%)
- BIM-implementation – 1 (0,8%)

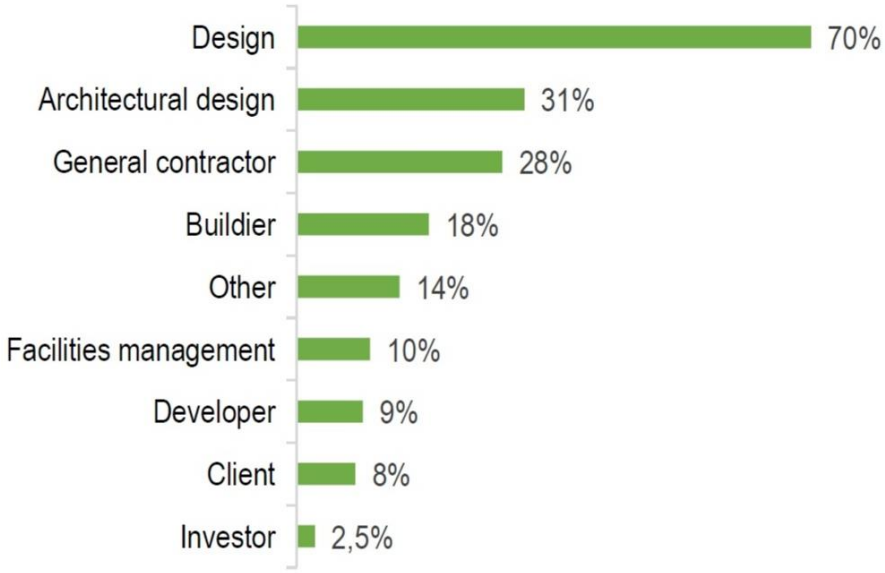

Figure 29. Scope of organizations activities

A role of responder within the organization:

1) Architect– 14 (11%)
2) Designer– 46 (37%)
3) Quantity surveyor – 6 (5%)
4) BIM-coordinator/BIM-manager– 13 (10%)
5) Team leader – 9 (8%)
6) Chief Project Engineer – 4 (4%)
7) Chief Project Architect – 4 (4%)
8) Chief Executive Officer – 6 (5%)

Responders options:

2 responders each (1,5%):

- Educational center expert and BIM specialist
- Engineer
- TO specialist

1 responder each (0,8%)

- Supervising foreman
- Master of construction works
- Labor protection specialist
- Project manager
- Building control

- BIM executive
- Project Implementation and Support Unit specialist
- Worker
- Construction support service engineer
- Head of 3D modelling department
- Chief specialist of 3D modelling department
- Lead architect/BIM coordinator within the group
- Fitting engineer
- Technologist

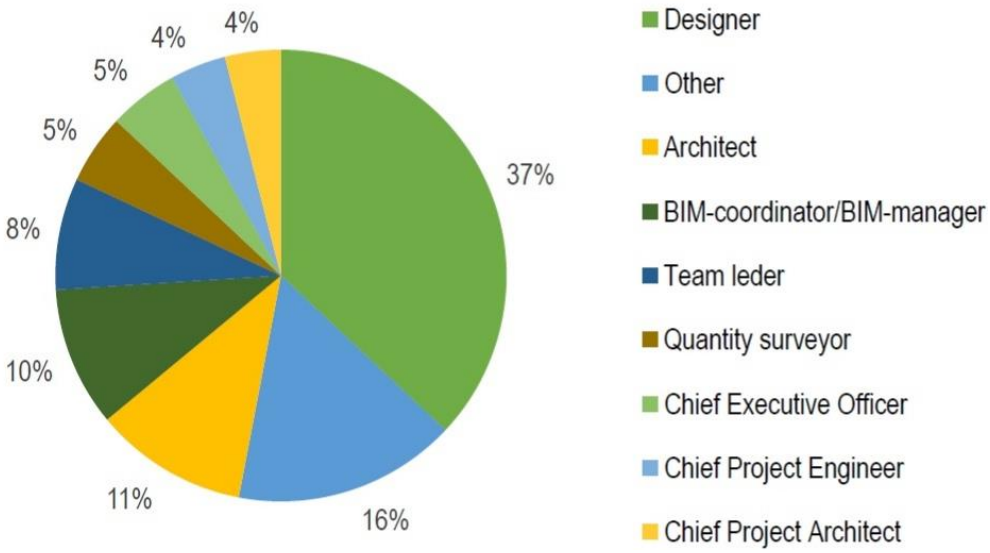

Figure 30. A role of responders

Age of responders:

1) Less than 25 – 51 (41%)
2) 26-35 y.o. – 50 (41%)
3) 36-45 y.o. – 17 (14%)
4) 46-55 y.o. – 3 (2,5)
5) 56-70 y.o. – 1 (0,8%)
6) More than 70 y.o. – 0 (0%)

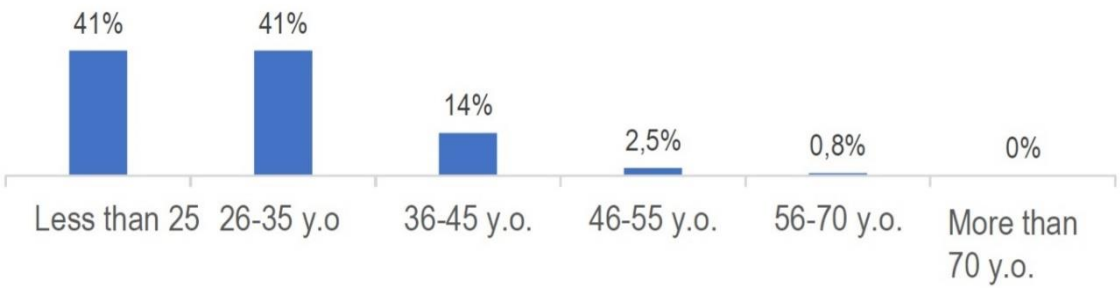

Figure 31. Age of responders

Experience of responders:

1) Less than 3 years – 47 (39%)
2) 3-5 years – 34 (28%)
3) 6-10 years – 17 (14%)
4) 11-20 years – 16 (13%)
5) 21-30 years – 7 (6%)
6) More than 30 years – 0 (0%)

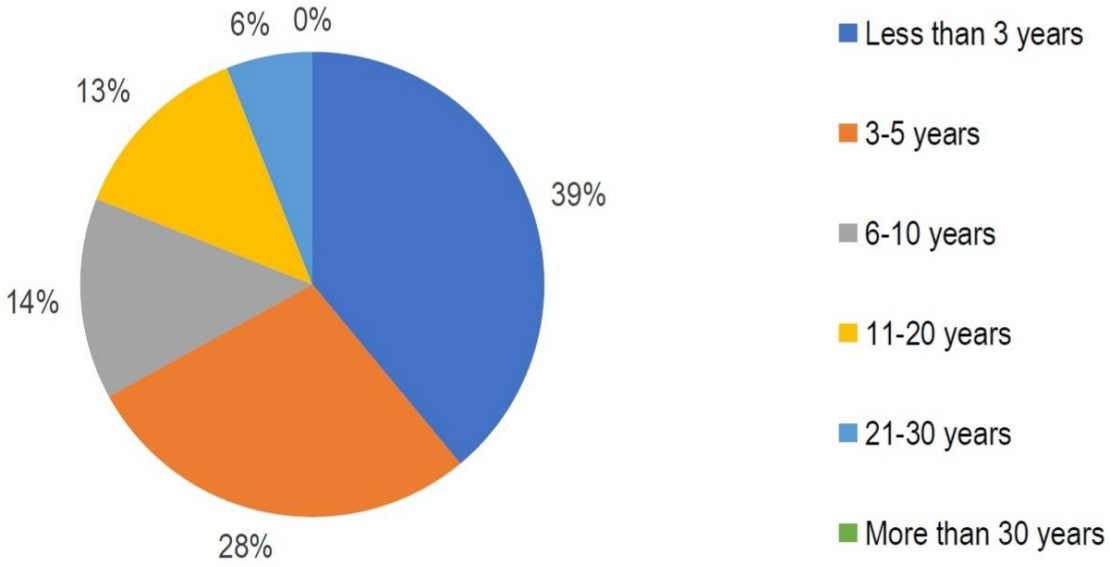

Figure 32. Experience of responders

122 resonders have taken a part in the survey representing 94 organizations. 80% of responders chose Saint-Peresburg as a region of their activity. The main areas of activity of the organizations are design and architectural design. Over a third of respondents are designers, and 21% of respondents are top managers. 82% of respondents are under the age of 36, and 67% have work experience before the age of 6.

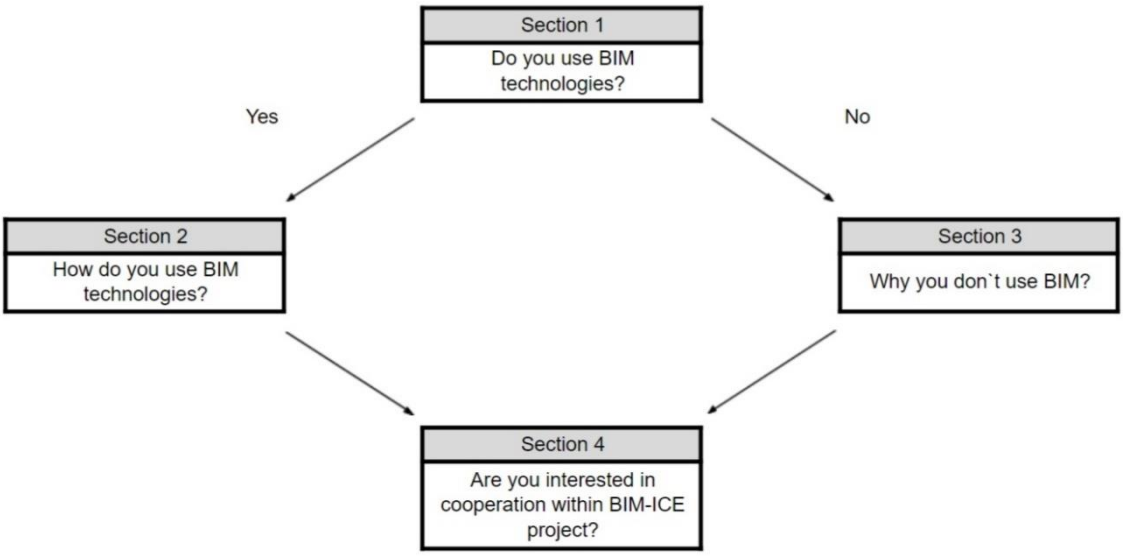

Figure 33. Employees questionnaire map

The figure above shows the principal structure of employees` survey.

5.2.2 Main survey questions and answers

1. Do you use BIM technologies in your work?

1) Yes in each project – 34 (28%)
2) Yes, not in every project – 39 (32%)
3) No – 49 (40%)

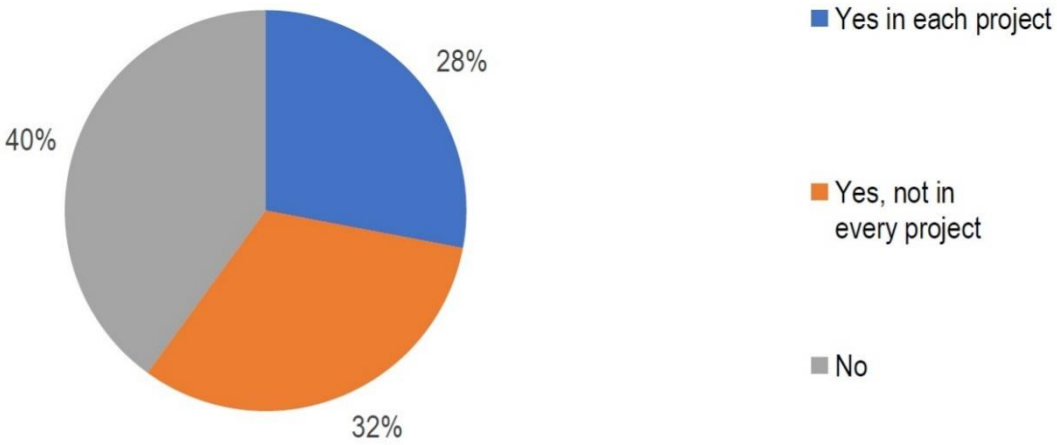

Figure 34. Usage of BIM in work

About a half of responders (39 organizations) don`t use BIM technologies in their work. Their profiles:

1) Developer– 0 (0%)
2) Investor – 0 (0%)
3) Client – 4 (10%)
4) General contractor – 9 (23%)
5) Builder– 7 (18%)
6) Architectural design – 3 (7%)
7) Design – 23 (59%)
8) Building operation – 4 (10%)

Responders options (one organization each profile – 2,5%):

- Object repair
- Mathematical modelling
- Examination of buildings and structures
- Shipbuilding
- Contractor
- Engineering systems provider
- Oil and gas
- Main heat networks

Organizations that use BIM technologies in their work have following profiles:

1) Developer– 7 (13%)
2) Investor – 3 (5%)
3) Client – 6 (11%)
4) General contractor – 24 (43%)
5) Builder – 13 (23%)
6) Architectural design – 31 (56%)
7) Design – 49 (89%)
8) Building operation – 7 (13%)

Responders options (one organization each profile – 1,5%):

- EPC - contractor
- BIM - integration

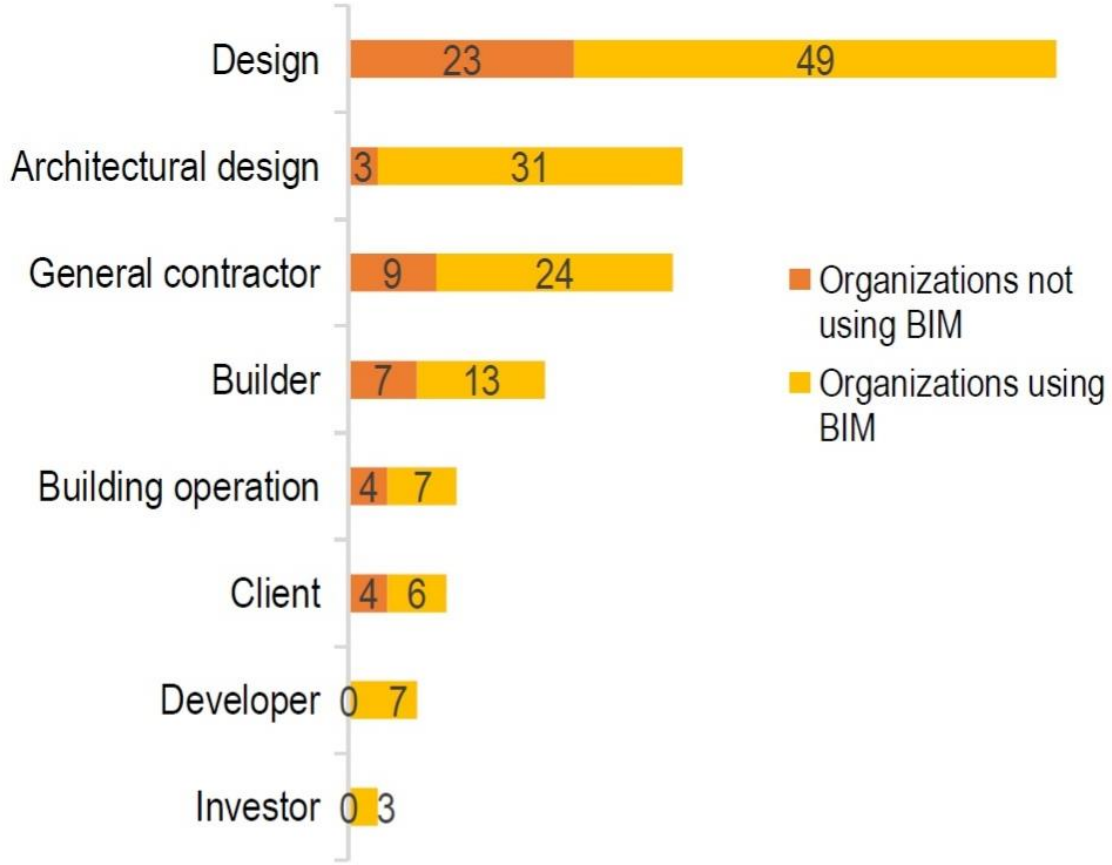

Figure 35. Profiles of organizations that use BIM

There are no developers or investors among organizations that do not use BIM at all. The ratio of BIM technology use to non-use is roughly equal among buildings management organizations. Most of developers, general contractors, design and architectural organizations are using BIM. Especially in the field of architectural design.

Those responders who doesn`t use BIM in their work were asked the following questions:

1.1. What is the reason for your organization not to use BIM technologies? (multiple choice)

1) Current amount of project does not allow to implement new technologies– 16 (32%)
2) Work of organizations is effective enough without BIM – 23 (47%)
3) Lack of normative regulations – 4 (8%)
4) Weak regulatory environment – 7 (14%)
5) Lack of qualified and competent specialists – 27 (55%)
6) Employees resist the innovations implementation – 10 (20%)
7) High implementation cost – 24 (49%)
8) Threat of sanctions on imported software – 5 (10%)

Responders options:

- Staff doesn`t want to use BIM! One of the main minuse of organization
- It is not clear could be given software used for heat network modelling
- All the project starts in a rush and staff use AutoCAD to make a draft because it is faster. As a result of constant rush the project stays in the same program because no one wants to use Revit being afraid of delay
- Client doesn`t want to increase cost of the project

Almost half of the responders indicated that the organization was effective without BIM, but only 7 out of 23 responders who chose this option said it was the only reason. External causes (indicated in pink) were chosen by the responders in a much smaller number of cases. Among the reasons why the organization does not use BIM are mostly internal (indicated in green) the most popular is the lack of qualified personnel.

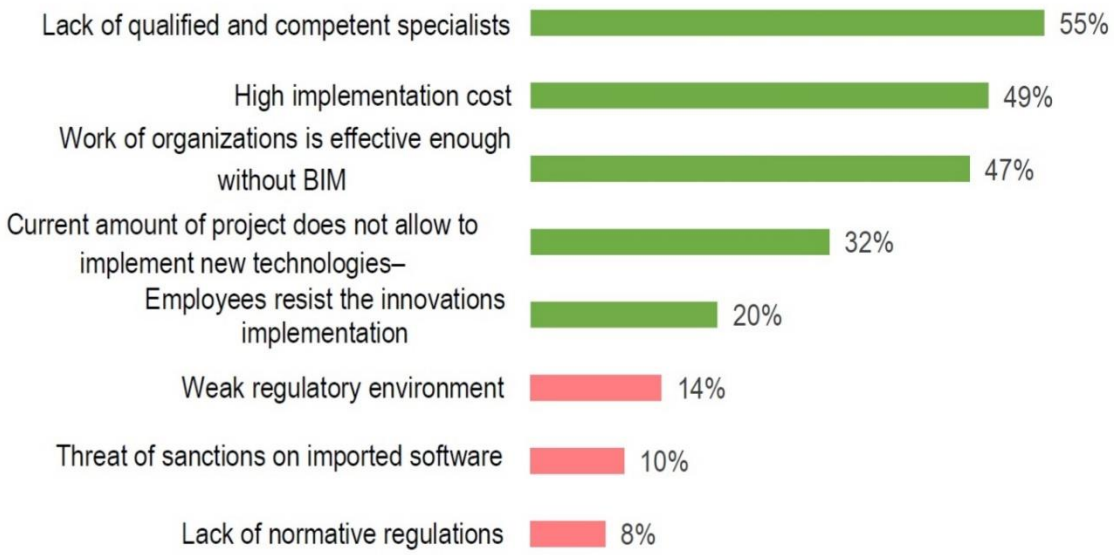

Figure 36. Reasons of not using BIM

1.2. Does your organization plan BIM implementation in near future?

1) Yes, this year – 1 (2%)
2) Yes, in the next 3 years – 2 (4%)
3) Yes, in the next 5 years – 5 (10%) (all 5 responders from the same organization)
4) No – 16 (32%)
5) It is hard to answer – 25 (51%)

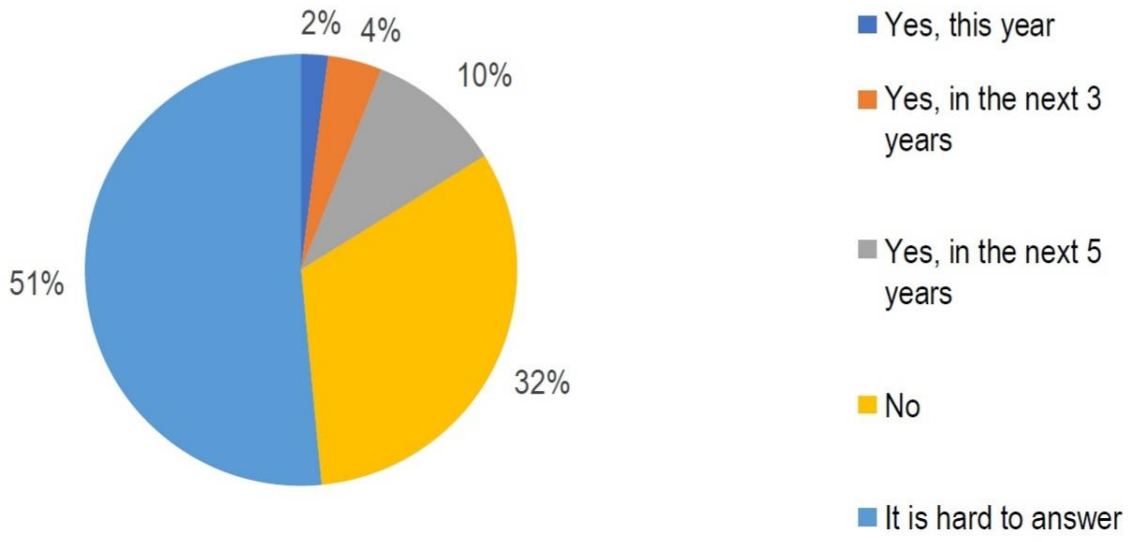

Figure 37. Future plan of BIM implementation

More than a half of responders found this question hard to answer. 32% of responders are confident that BIM implementation is not on the agenda and almost all of them (except two) believe that the organization's work is efficient without using BIM.

1.3. What external or domestic reasons can make your organization to use BIM technologies? (multiple choice)

1) Mentorship of experienced BIM professional – 18 (36%)
2) Expertise demand of other normative document – 32 (65%)
3) Having enough money to implement and reorganize process – 23 (47%)
4) Software cost reduction – 19 (39%)
5) Availability and effectiveness of domestic software – 12 (24%)
6) Heads of organization decision – 39 (80%)
7) Client demands – 29 (60%)
8) Government order – 20 (40%)

Responders options:

- I hope that nothing
- Qualified collegaues
- We don`t need BIM at all

Figure 38. Reasons to use BIM

According to the survey most of responders (80%) consider that BIM implementation will be the decision of the heads of organizations. External demands such as laws and norms are important for 65% of responders and 28% are ready to follow the demands of the client. Less than a half of responders consider that money will be the main reason in future BIM implementation decision.

1.4. What effect do you expect after BIM implementation? (multiple choice)

1) BIM increase competitiveness – 16 (32%)
2) Increase an income in perspective – 21 (43%)
3) Increase the amount of orders – 7 (14%)
4) BIM implementation is economically wrong decision – 11 (22%)
5) It will bring big difficulties to the team – 15 (30%)
6) It will be the reason of projects amount reduction and increase in project delivery time – 6 (12%)

Responders options:

- It will reduce design time and simplify engineering systems design
- It will require training of all personnel, but in the long term it will shorten the working time.
- Will increase the speed of transmission of information within the company, will simplify communication between the engineers

- Nothing will change since the aim is not to project in BIM , but to give the value of the object on the systems of our organization

Figure 39. Expectations about BIM implementation

Most of responders (40%) consider that BIM implementation will be economically justified and chose exclusively positive factors (indicated in green). 24% of responders chose exclusively negative factors (indicated in orange). Others consider that BIM implementation is a mix of positive and negative factors.

1.5. Does your organization plan BIM trainings and how will it be organized?

1) Yes, by our own – 1 (2%)
2) Yes, with the help of corporate universities or with outside expertise – 4 (8%)
3) Yes with help of multiple training programmes on collaboration with educational organizations – 1 (2%)
4) No, we hire employees that already qualified in BIM – 1 (2%)
5) Not planned – 19 (39%)
6) It is hard to answer – 24 (48%)

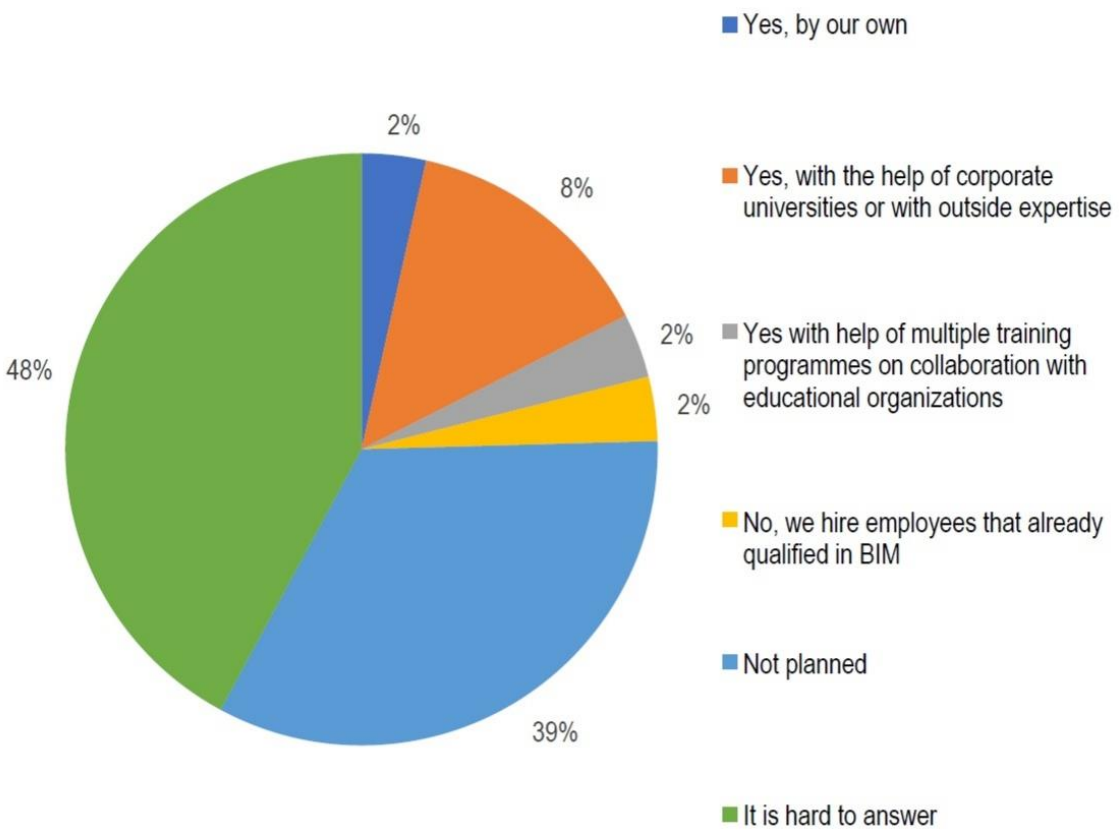

Figure 40. BIM trainings planning

6 responders (12%) answered that BIM training are planned but only 3 of them indicated that BIM implementation is planned in their organizations. In all the rest organizations apart one (who are not going to implement BIM at all) BIM trainings are not a part of organization`s plan.

Next block of questions is intended for those responders who use BIM in the project work. 73 responders from 55 organizations were asked the following questions:

2. What are the reasons of BIM implementation on your organization? (multiple choice)

1) Clients demands – 39 (53%)
2) Project quality improvement – 53 (72%)
3) Improving competitiveness – 45 (61%)
4) Reduction in cost and time, improving profitability – 30 (41%)
5) Changes in law and demands of regulatory environment – 11 (15%)
6) Increase in amount of requests on BIM-based projects – 32 (44%)

Responders options:

- BIM is a daily working instrucment

- Market trend
- Business base

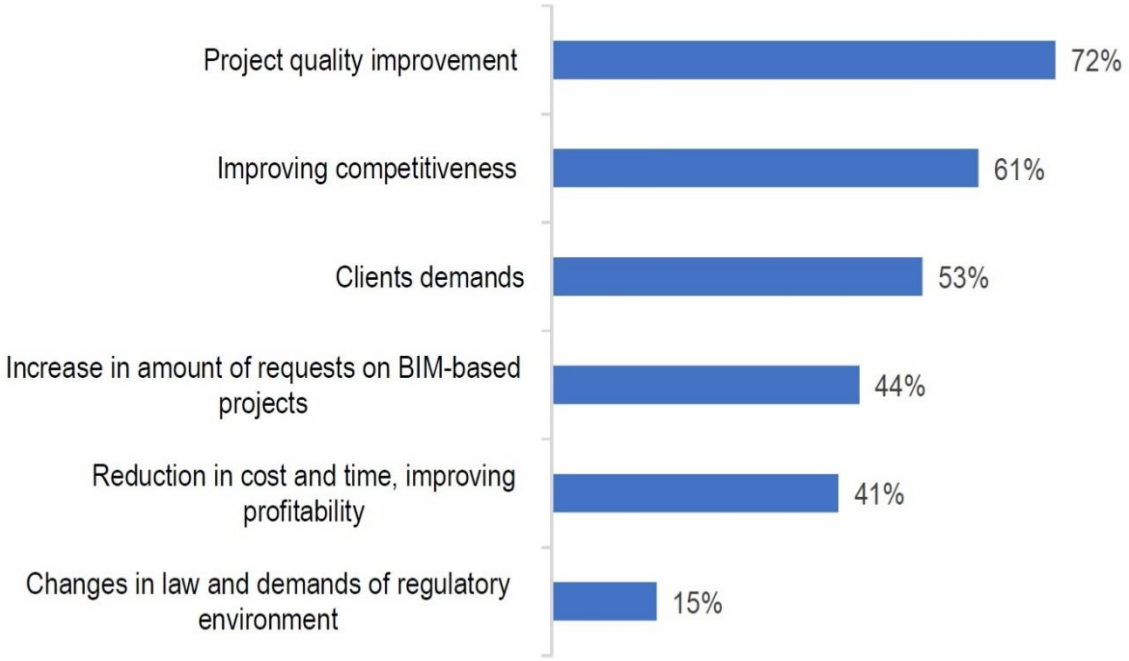

Figure 41. Reasons of BIM implementation

Project quality improvement is the most widespread (45 – 61%) internal reason and client demands is the most popular (39 – 53%) external reason. The least important reasons were economical (“Reduction in cost and time, improving profitability”) and regulatory (“Changes in law and demands of regulatory environment”). It is worth to point out that most of responders chose internal reasons.

3. Total number of projects (both completed and in progress) implemented by the organization in the last 5 years:

1) Less than 10 – 22 (31%)
2) 10-30 – 17 (24%)
3) 30-50 – 15 (20%)
4) 50-100 – 12 (16%)
5) More than 100 – 7 (9%)

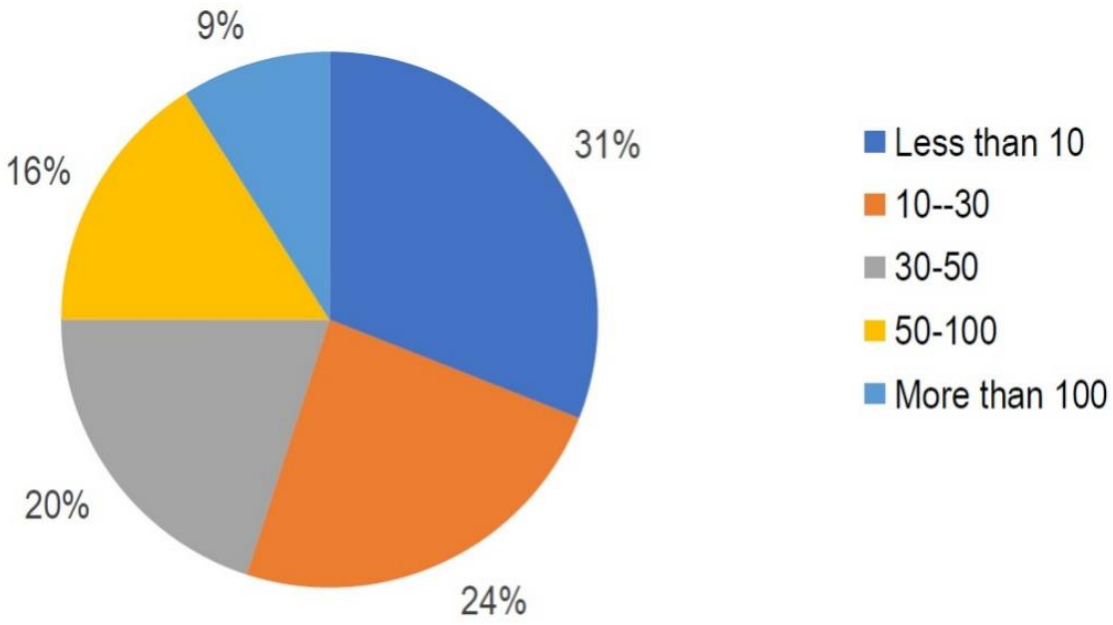

Figure 42. Total number of projects by the last 5 years

Only 34 responders (45%) indicated that they have more than a 30

4. Choose the amount of projects implemented with using BIM technologies

1) 1-5 – 33 (46%)
2) 5-10 – 18 (24%)
3) 10-30 – 8 (11%)
4) More than 30 – 14 (19%)

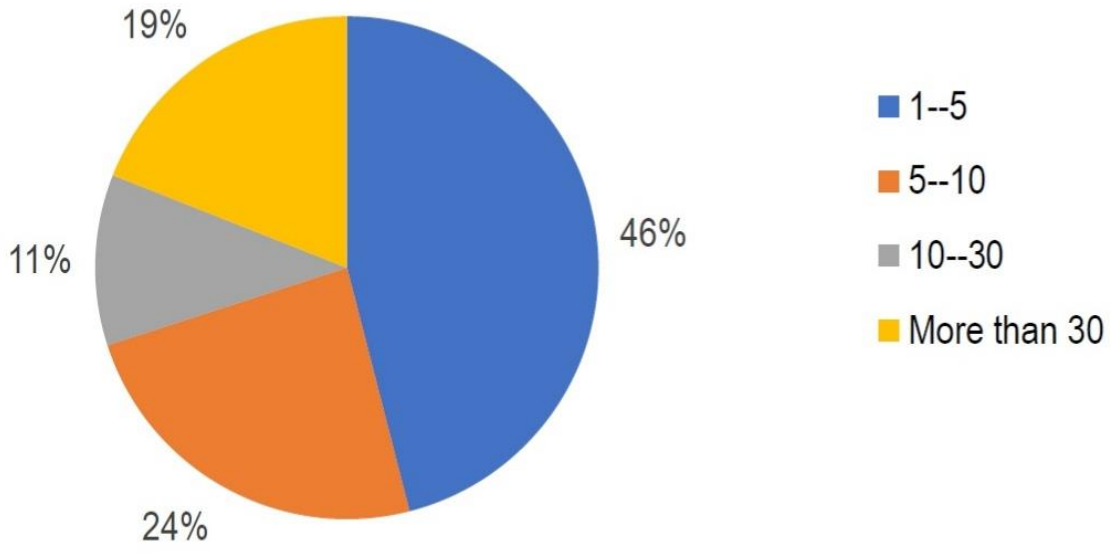

Figure 43. Amount of BIM projects

Almost a half of organizations using BIM in their work have 1-5 BIM projects n their portfolio. That indicates that this technology has adapted to the Russian market and more and more organizations implement BIM in their work. 13 organizations out of 14 which has more than 30 implemented BIM projects use BIM in each project. 24 organizations out of 33 which has 1-5 BIM projects use BIM not in each project.

5. How long has your company been using BIM technologies?

1) Less than a year – 10 (13%)
2) 1 - 3 years – 24 (33%)
3) 3 - 5 years – 20 (27%)
4) More than 5 years – 19 (26%)

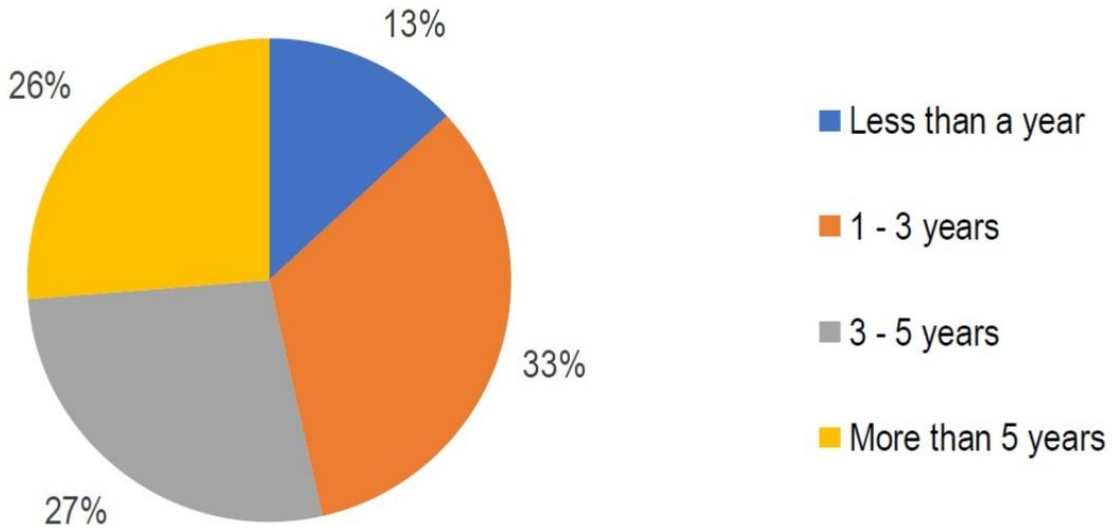

Figure 44. How long do you use BIM

Most organizations have had experience with BIM technology for more than three years (53%). All but one of the organizations using BIM less than a year have completed 1-5 projects using this technology. Organizations that have implemented more than 30 projects using BIM have always used BIM for more than 3 years and 70% for more than 5 years.

In addition, these organizations use BIM to work on all projects. Thus, the number of completed BIM projects increases with the increase in the lifetime of these technologies, which may indirectly confirm the effectiveness of BIM technologies and the satisfaction with their use.

6. Specify the purpose of the objects implemented by your organization using BIM technologies (multiple choice)

1) Buildings and structures for production – 36 (49%)
2) Linear objects of engineering systems – 18 (24%)
3) High-risk areas – 11 (15%)
4) Highways – 7 (10%)
5) Railwys – 1 (1,5%)
6) Reconstruction and renovation facilities – 16 (22%)
7) Public buildings – 41 (56%)
8) Housing development – 39 (53%)
9) Cultural heritage objects – 10 (14%)
10) Healthcare objects – 12 (16%)

Responders options:

- Social objects
- Infrastructure objects
- Construction and reconstruction of water treatment plants

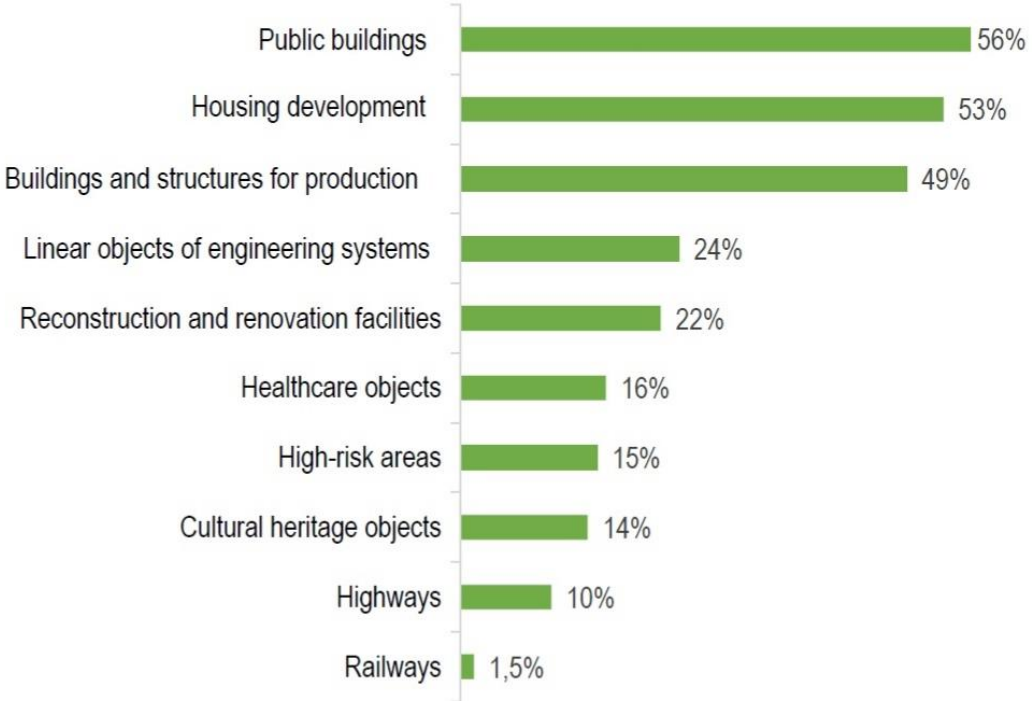

Figure 45. Purpose of the BIM projects

Generally, respondents chose 2-3 assignments for completed objects. More than half of the organizations operated public buildings and residential buildings using BIM. BIM was the least used in road and rail work. Accordingly, organizations have a variety of projects in their portfolio.

7. What software and BIM platforms does your organization use to develop BIM models? (multiple choice)

1) Autodesk Revit – 63 (86%)
2) Autodesk Civil 3D – 26 (35%)
3) Autodesk Navisworks – 40 (54%)
4) Autodesk Infraworks – 9 (13%)
5) Autodesk Advance Steel – 10 (14%)
6) Autodesk Robot – 8 (11%)
7) ArchiCAD – 13 (18%)
8) Allplan – 2 (2%)
9) Solibri – 3 (4%)
10) SCIA Engineer – 1 (1,5%)
11) Bentley Staad.PRO – 0 (0%)
12) Bentley OpenBuildings Designer – 2 (2%)
13) Bentley MicroStation – 2 (2%)
14) Bentley SITEOPS – 0 (0%)
15) Tekla – 21 (29%)
16) Renga – 4 (5%)
17) NanoCAD Engineering BIM – 1 (1,5%)
18) NanoCAD Structure BIM – 1 (1,5%)
19) Sapfire 3D – 2 (2%)
20) AVEVA – 2 (2%)
21) SketchUP – 10 (14%)
22) Grasshoper – 2 (2%)
23) Dlubal RFEM – 1 (1,5%)
24) BricsCAD – 1 (1,5%)

Responders options:

- Rhinoceros
- Topomatic Robur – Highways
- MagiCAD
- Enscape
- Autodesk Dynamo
- S-INFO
- Robur
- NanoCAD

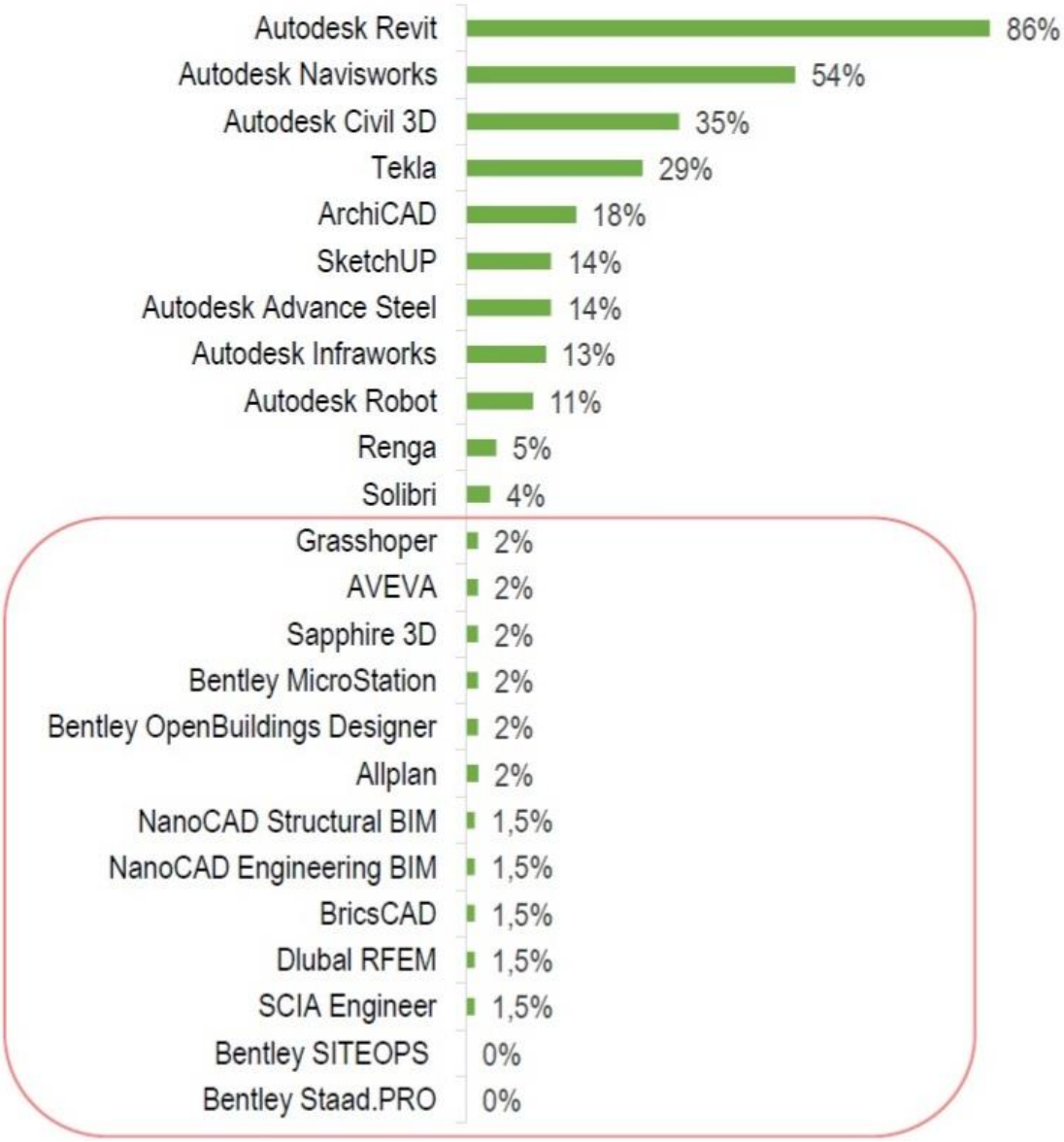

Figure 46. Software and BIM platforms that are in use

More than half of the proposed options (13 out of 24) were selected by 1-2 responders or were not selected at all. None of the options were chosen by all respondents. The most popular software for BIM development is Autodesk Revit and Autodesk Navisworks. Generally, responders chose three options.

8. What software and BIM platforms does your organization use for BIM models review? (multiple choice)

1) Autodesk Navisworks – 49 (67%)
2) Autodesk BIM 360 – 32 (44%)
3) Graphisoft BIMcloud – 4 (5%)

4) Graphisoft BIMx – 5 (6%)
5) Solibri – 3 (4%)
6) Bentley ProjectWise – 2 (2%)
7) Bentley Navigator – 0 (0%)
8) Trimble Connect – 3 (4%)
9) Bim Vision – 4 (5%)

Responder options:

- BIMTangle
- DDS-CAD Viewer
- FZKV Viewer
- Enscape
- Autodesk Viewer
- ITWO
- Revit
- S-INFO
- Robur
- Credo

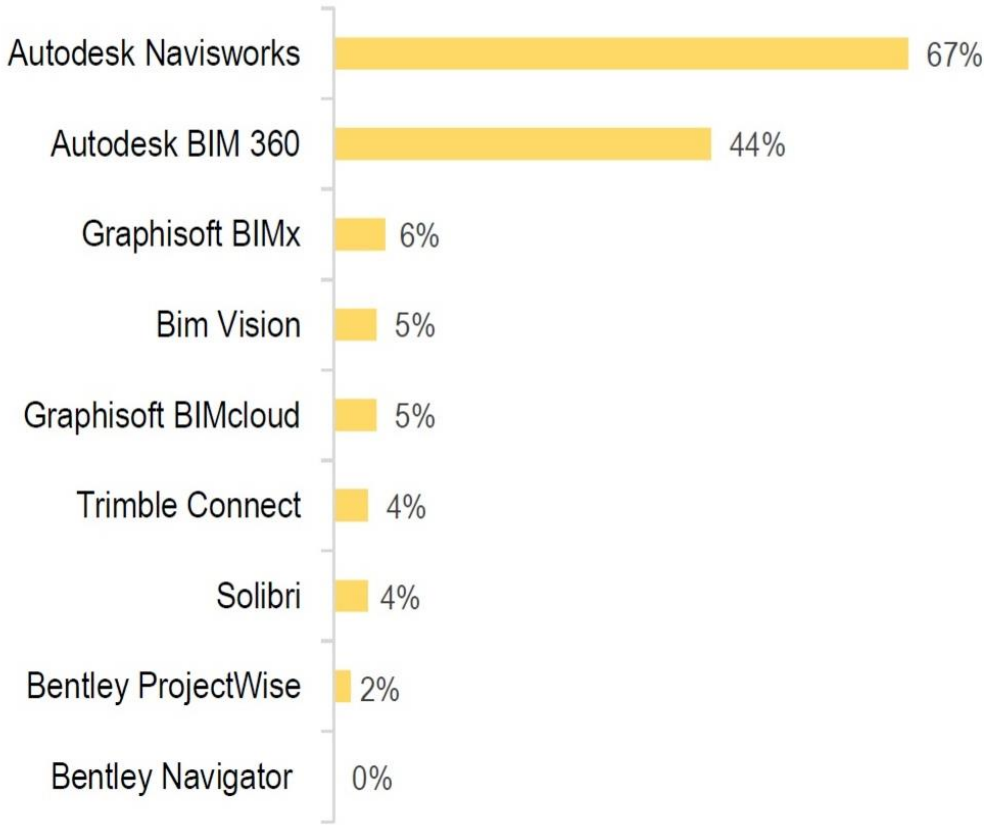

Figure 47. BIM platforms to review models

The most popular software among responders are Autodesk Navisworks (49 – 67%) and Autodesk BIM 360 (32 – 44%). All the other software platforms were chosen by only 21 (26%) responders.

9. Do you use the following digital tools when working on projects? (multiple choice)

1) Digital twin – 10 (14%)
2) Internet of Things – 2 (2%)
3) Virtual or Augmented reality – 10 (14%)
4) Common Data Environment– 26 (35%)
5) BCF – 5 (7%)
6) IFC – 48 (66%)
7) Nothing from listed above – 18 (25%)

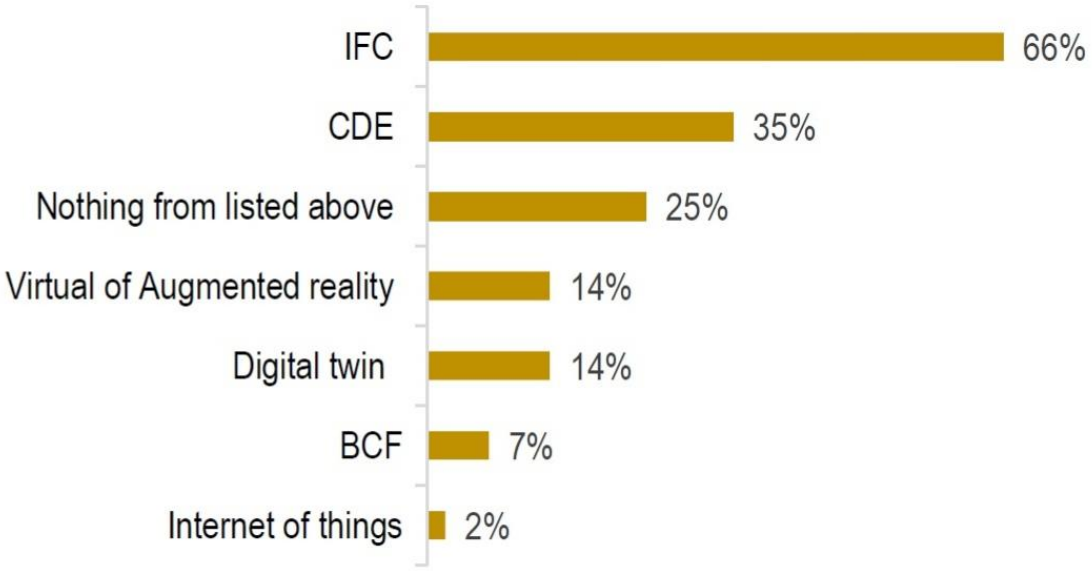

Figure 48. Digital tools usage

More than half of the responders referred to the IFC format, slightly more than a third to the common data environment. The other tools offered are less used. Responders tended to choose two technologies.

A quarter of the respondents did not use the tools listed. Most of them work in organizations that use BIM-technologies for less than 3 years having up to 5 BIM projects and apply BIM not in every project. Thus, it can be concluded that a small number of projects can be carried out by an organization without BIM, and the more organization use BIM the more number of used digital tools.

10. Have you used laser scanning technology and a cloud of points in your work on projects and for what purposes? (multiple choice)

1) Yes the points cloud was used during the site modelling – 8 (11%)
2) Yes, it was using as one of the data source in existing building modelling process – 24 (33%)
3) Yes, we used this technology during the stage change to «as built» – 9 (12%)
4) Yes, in process of automated modelling the points cloud data – 2 (2%)
5) Yes, we did quantity control with help of point cloud – 3 (4%)
6) Yes, we created the point cloud as a basis of future renovation – 7 (9%)
7) We did not use laser scanning and point cloud – 41 (56%)

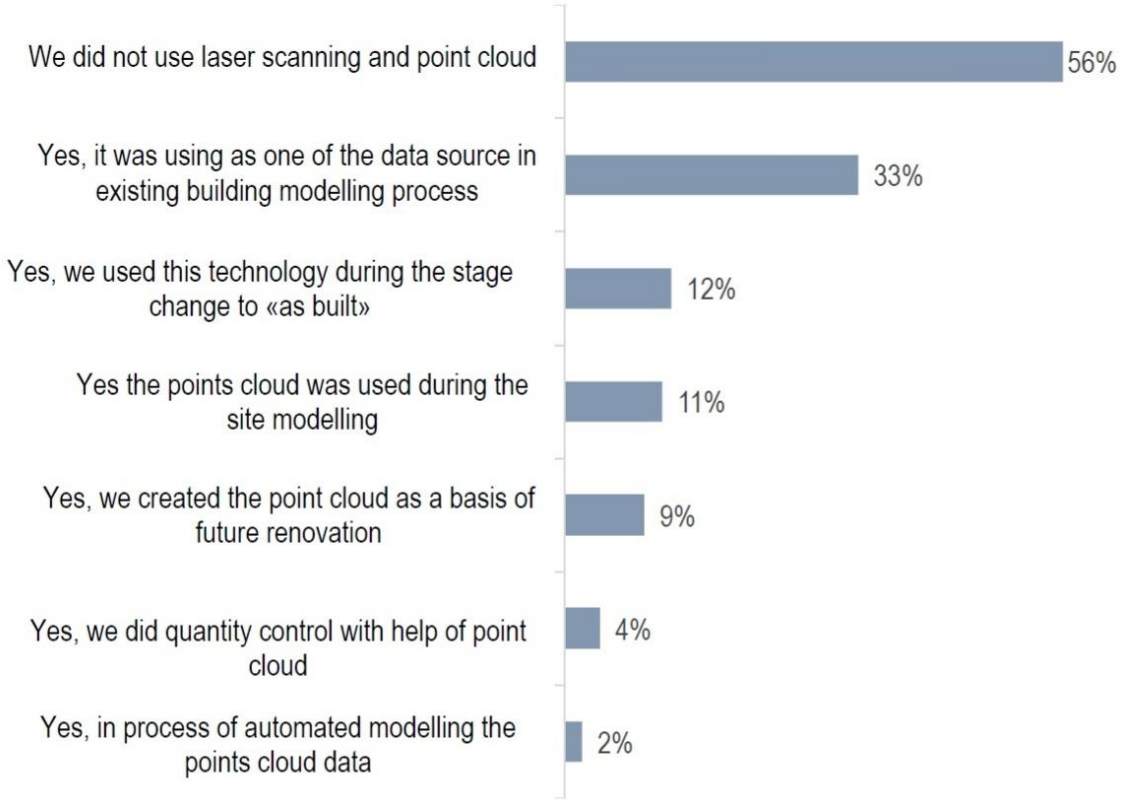

Figure 49. Laser scanning and point clouds usage

More than a half of responders did not use laser scanning and point clouds (41 – 56%) and less than a half indicated that they used point cloud as a data source in existing building modelling process (33%). The least popular answer was using point cloud dada in automated modelling – only 2 responders (2%). The use of laser scanning and point clouds is not related to the quality of the organizations. The technologies are used equally by different organizations, with different project portfolio and BIM experience.

11. Are you familiar with OPEN BIM standards and do you use them in your work?

1) Yes, familiar and use – 15 (20%)
2) Familiar and plan to use – 8 (11%)
3) Familiar but do not use – 18 (25%)
4) Not familiar and don`t use – 32 (44%)

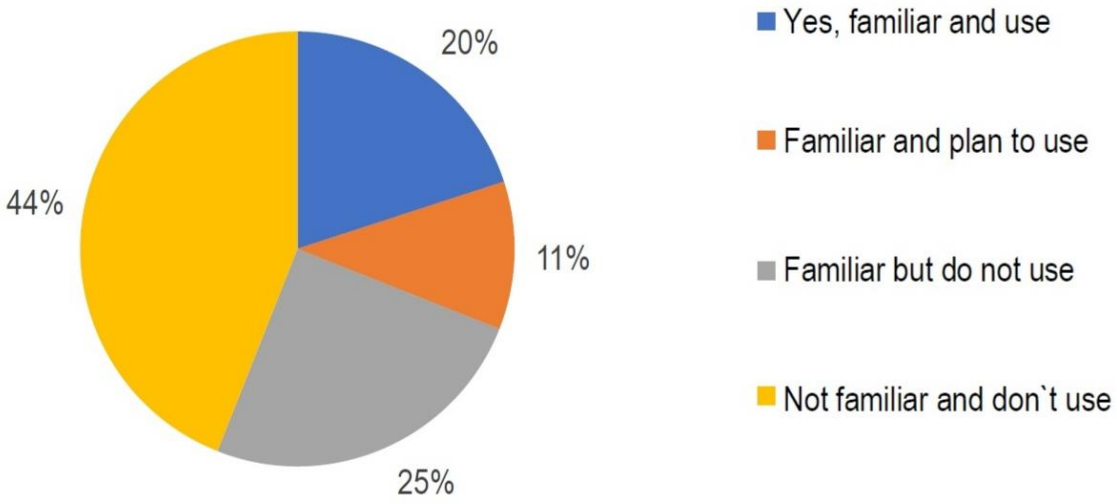

Figure 50. How the organizations are familiar with Open BIM standards

Almost half of the responders are unfamiliar with the OPEN BIM standards and do not use them. Also half of them do not use laser scanning and point cloud technologies and use BIM technologies in their work on all projects. Among respondents that use Open BIM standards in their work, more than half are BIM coordinators/BIM managers, 60% of them also have work experience for more than 10 years.

12. What methods of data transfer between software products does your organization apply? (multiple choice)

    1) Export/Import through IFC – 50 (68%)
    2) Export/Import through DWG – 54 (74%)
    3) Export/Import through DXF – 24 (33%)
    4) Export/Import through DWF – 14 (19%)
    5) Using plugins that help to export initial model into needed formats (for example: export Revit format directly in SketchUp) – 24 (33%)

Responders options:

- Own project data exchange ways
- Cpixml

- .nwd
- FBX

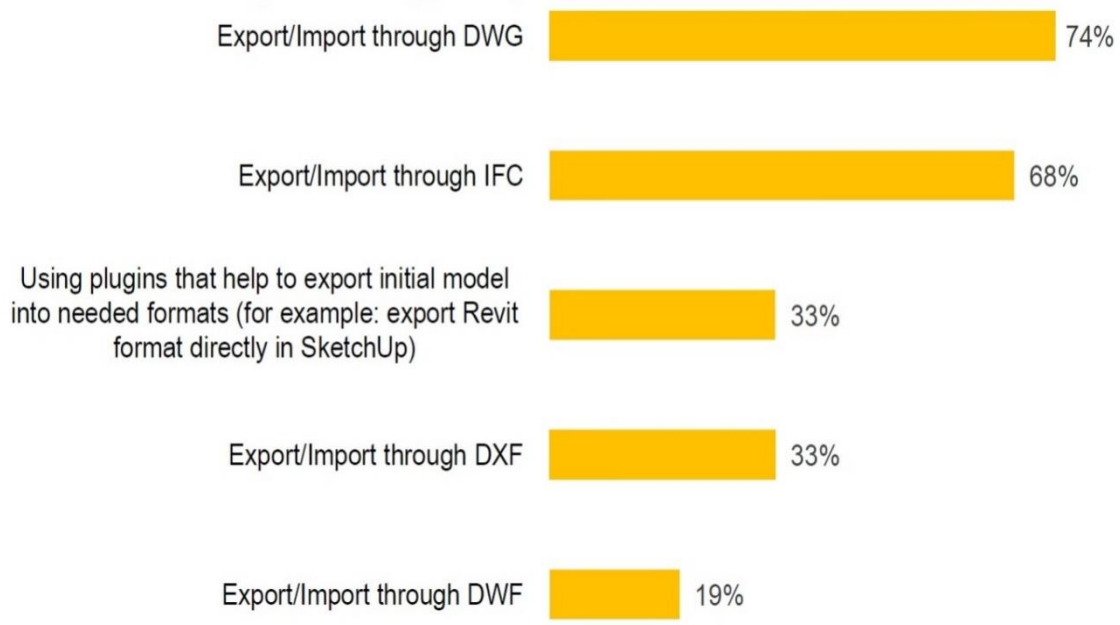

Figure 51. Data transfer methods

The most used ways of transferring data between software products are export/import through the IFC format and export/import through the DWG format. Respondents generally chose 2-3 options.

13. What method of data exchange between specialists is used in your organization? (multiple choice)

1) Email – 50 (68%)
2) External storage – 11 (15%)
3) Local network – 57 (78%)
4) CDE – 25 (34%)
5) Cloud platforms (OneDrive, Yandex Disk, Dropbox and so on) – 27 (37%)
6) Special platforms for BIM Data exchange (BIM 360 and so on) – 17 (23%)

Responders options:

- In-house workflow system
- Autodesk Vault
- Corporative cloud
- Socopro

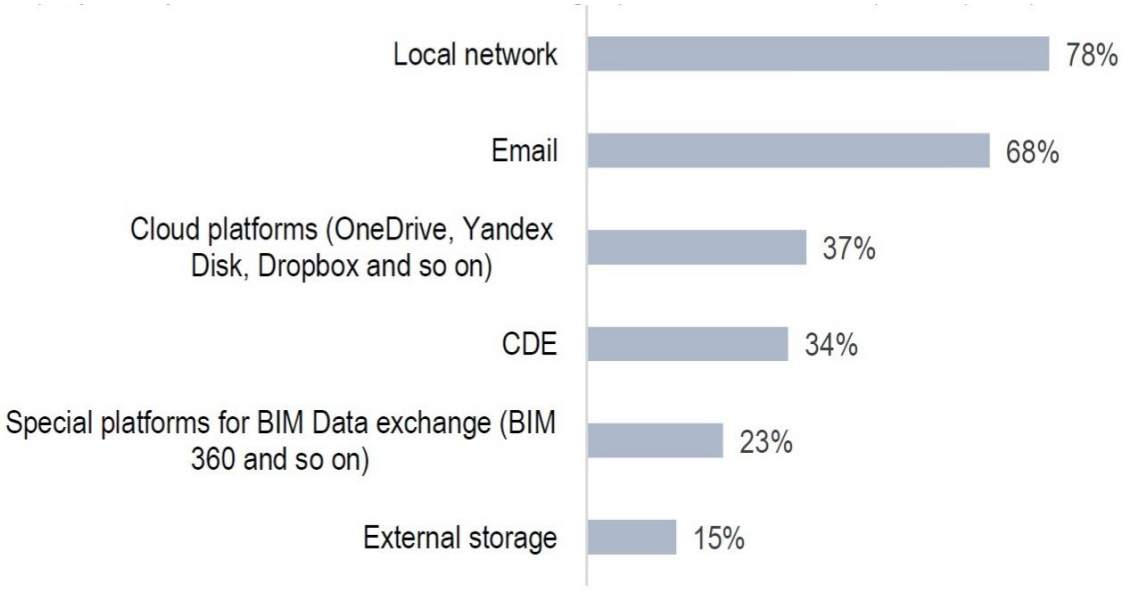

Figure 52. Data exchange methods

Most data exchange between specialists is done using the organization's local network and e-mail. Specialized BIM data exchange platforms are used by just under a quarter of the respondents, and in each case they use also other data exchange tools.

14. How do you create the drawings and the BIM model of the object?

1) We get all the drawing from BIM model – 41 (56%)
2) Create BIM model using already existing documentation – 7 (10%)
3) Create drawings based on BIM model and improving them in CAD software – 25 (34%)

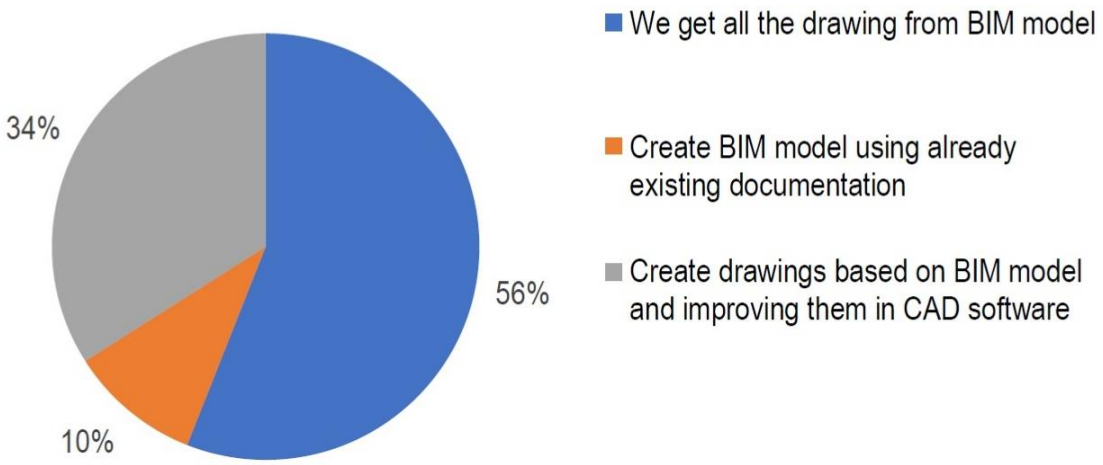

Figure 53. Drawings creation

More than half of the respondents create all drawings based on the information model, just over half of them use BIM in all projects. Among those who partially construct drawings

based on the information model, by refining them in the CAD complex, almost everyone uses BIM in not all projects.

15. Compare the expectations of BIM implementation with it`s real effect on a scale of 0 to 5:

1) 0 – It is hard to answer – 5 (7%)
2) 1 – results are absolutely mismatch expectations – 1 (1,5%)
3) 2 – real effect mostly mismatch expectations – 5 (7%)
4) 3 – results more match expectations than not – 27 (37%)
5) 4 – gained effect completely match the expectations – 29 (40%)
6) 5 – real effect exceeds expectations many times over – 6 (8%)

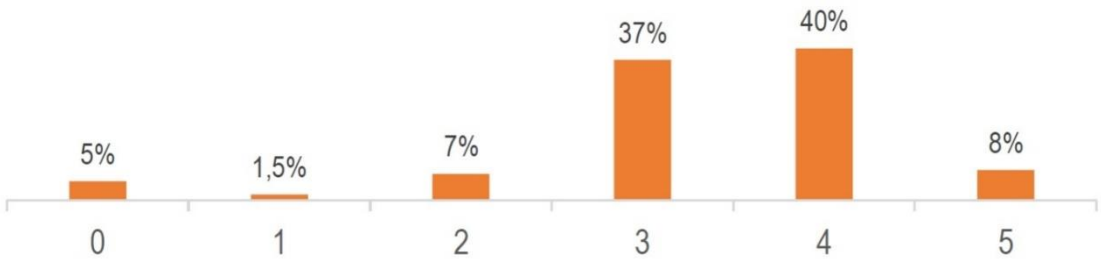

Figure 54. BIM expectations and real effect

For most responders expectations of BIM implementation correspond to or exceed the real impact of technology usage, indicating a high level of satisfaction.

Among those responders whose expectations are partially or completely not met, all work in organizations that do not use BIM in all projects and have no more than 5 BIM projects. Among those with a real impact that exceeds expectations all organizations use BIM in all projects implemented BIM more than three years ago and create all drawings based on the information model.

16. Advantages that BIM implementation provides: (multiple choice)

1) Accessibility of information for all the project participants, rapid information and data exchange – 52 (71%)
2) Understanding the scope of the project among all the project members – 51 (69%)
3) 3D and 4D project visualization – 54 (73%)
4) Design time reduction – 23 (31%)
5) Cost reduction – 11 (15%)

6) Project quality improvement – 58 (79%)
7) Increase in income and profitability – 13 (18%)
8) Rational and efficient use of resources – 20 (27%)

Responders options:

- There are no advantages
- Achieving Data Transparency at Life Cycle Stages
- BIM-team, is constantly acting instrument to improve and automate processes in project team

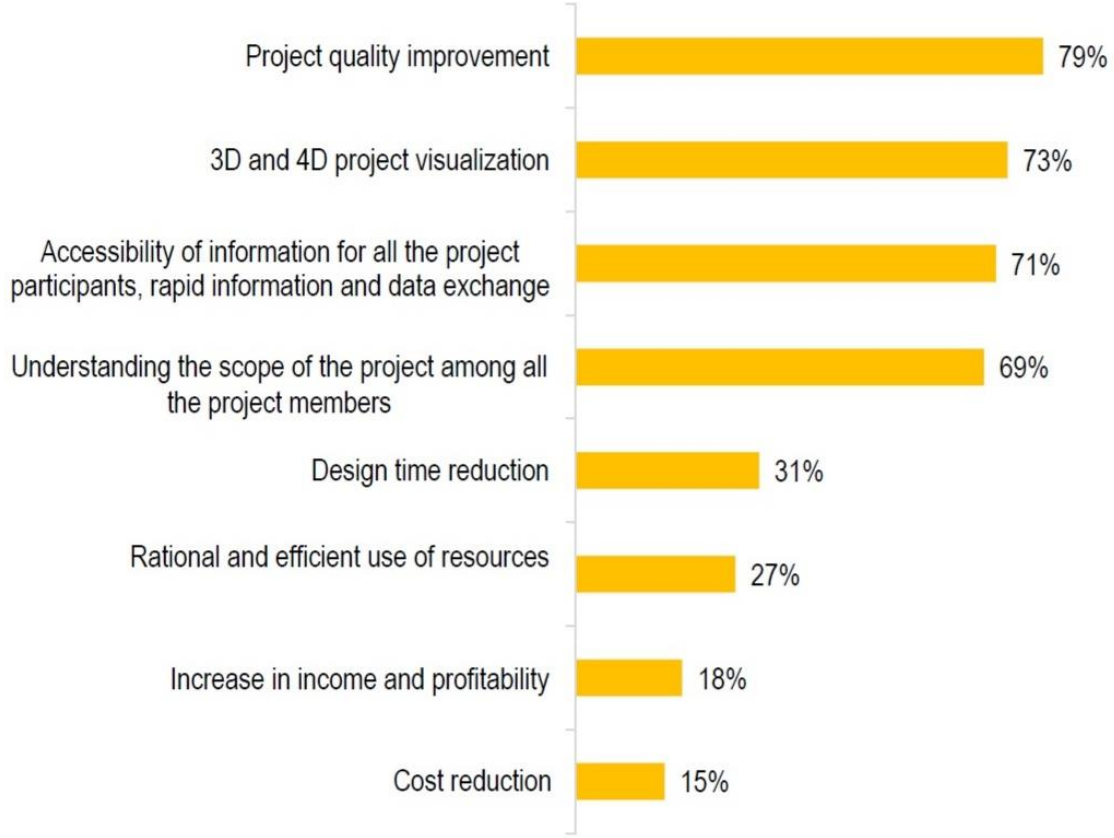

Figure 55. BIM advantages

Accessibility of information for all the project participants, rapid information and data exchange; understanding the scope of the project among all the project members; 3D and 4D project visualization and project quality improvement are the most popular advantages among responders. The least popular if an increase in income and profitability (13 – 18%). It is worth to point out that even those responders who indicated that the impact of BIM implementation did not meet their expectations chose 1-2 advantages. The remaining respondents tended to choose about 3-4 advantages.

17. Difficulties in using BIM technologies: (multiple choice)

1) Resistance to change and innovations among employees – 29 (40%)
2) Lack of a system of State standards for the implementation of BIM-based projects – 23 (31%)
3) Lack of qualified employees, BIM managers in organization – 55 (75%)
4) Lack of domestic software and data bases, impossibility of complete import substitution – 26 (35%)
5) Lack of necessary interaction between different sections of the project – 20 (27%)
6) Differences in designing time among different project stages – 18 (24%)
7) Project expertise – 8 (11%)

Responders options:

- Weak PC, complexity in CDE creation
- Lack of qualified clients
- When everyone understands the technology there is no difficulties
- When you have to export a model from one software to another to do what you need and to do it you have to be experienced in different programmes, plugins (draft in one software, the rest project in another and so on…)

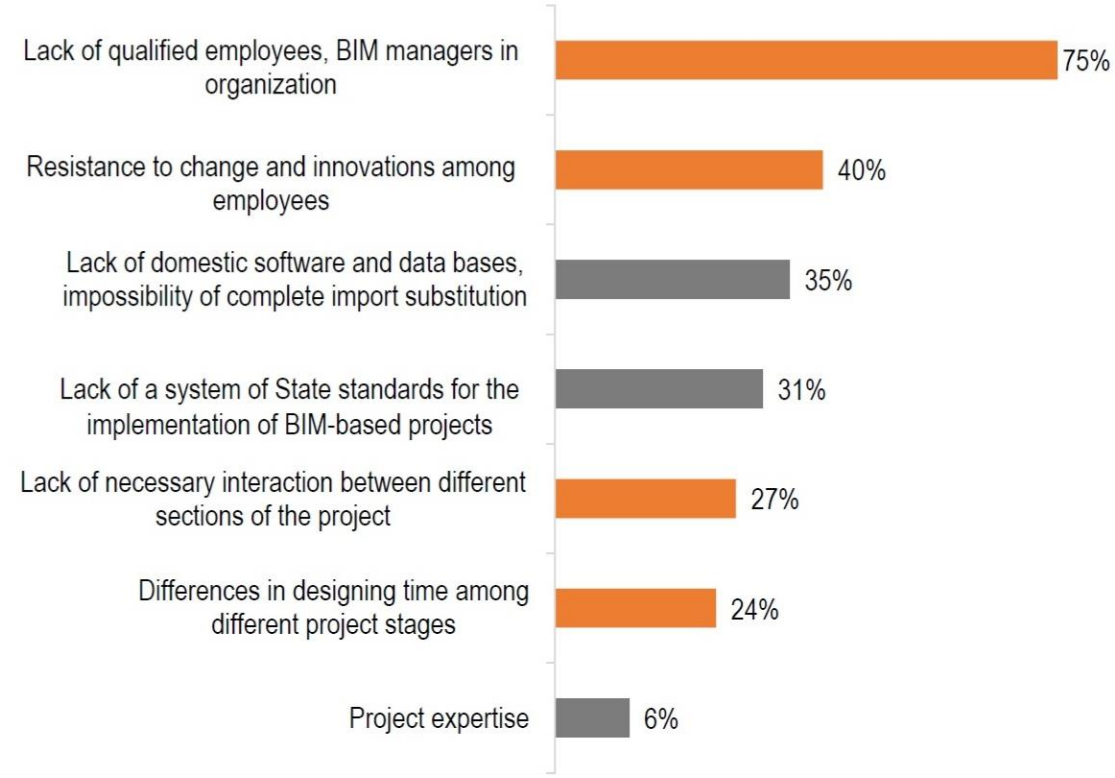

Figure 56. BIM usage difficulties

Most of responders indicated lack of qualified employees and BIM managers in organization as the most difficult in the process of using and implementing of BIM technologies. Project expertise is the least problem according to responders.

Also, internal difficulties were the most frequently selected by respondents (indicated in orange), external difficulties (indicated in grey) were not more than a third of the respondents.

18. Does your organization plan BIM trainings and how will it be organized?

1) Yes, by our own – 28 (39%)
2) Yes, with the help of corporate universities or with outside expertise – 10 (14%)
3) Yes with help of multiple training programmes on collaboration with educational organizations – 4 (5%)
4) No, we hire employees that already qualified in BIM – 13 (18%)
5) Not planned – 6 (8%)
6) It is hard to answer – 12 (16%)

76% of the responders said that their organization planned to train staff in BIM technologies and tools.

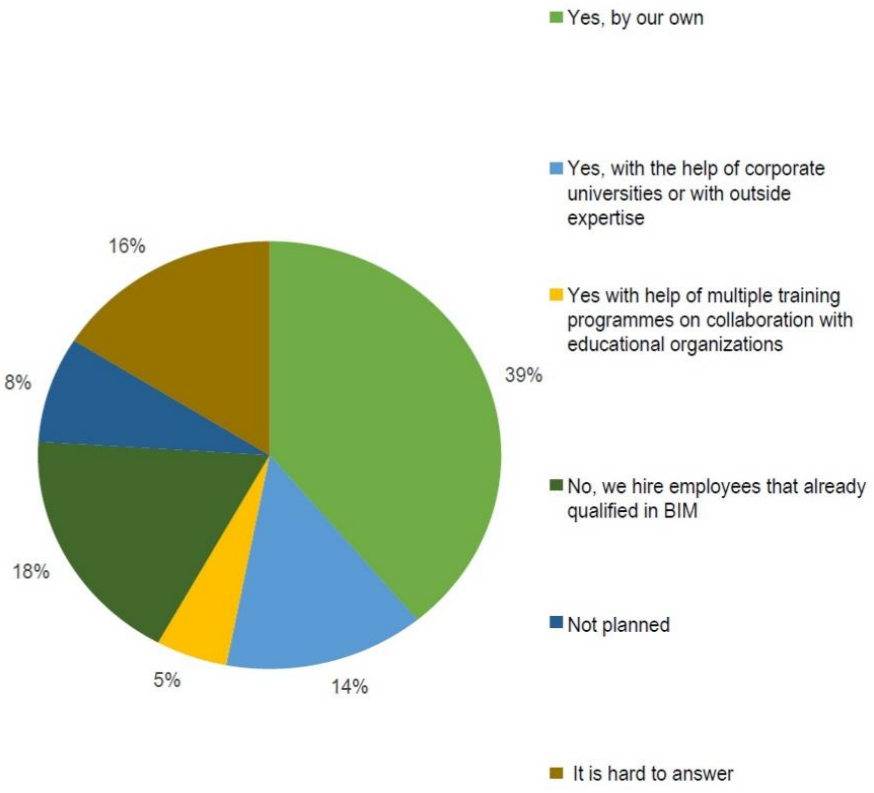

Figure 57. BIM trainings planning

Almost all organizations that hire staff with the necessary competencies use BIM in all projects. However, they all note a lack of staff with the necessary competencies and resistance of staff to innovation.

Organizations with no training plans have no more than 10 completed projects in the last 5 years and no more than 5 implemented in BIM.

Organizations with, in most cases, more than 30 completed projects and more than 3 years of experience with BIM plan to train their own staff.

Among those planning external training, such as development programmes, all organizations do not use BIM in all projects and, on average, have no more than 10 BIM projects.

19. Evaluate the qualifications of the graduates from construction universities in the field of BIM-technologies on a scale of 0 to 5, where:

- 0 – it is hard to answer – 11 (15%)
- 1 – graduates are not familiar with BIM-technologies and not trained in any programs to work with BIM-models – 10 (13%)
- 2 – graduates are familiar with the basics of one or more BIM programs but are in need of additional training – 32 (44%)
- 3 – BIM technology graduates generally meet company expectations, graduates are able to work in the right programs – 16 (22%)
- 4 – graduates of construction universities are fully trained in all necessary programs and technologies of work in BIM environment – 3 (4%)
- 5 – the level of ownership of BIM graduates generally exceeds the level of the company's employees – 1 (1,5%)

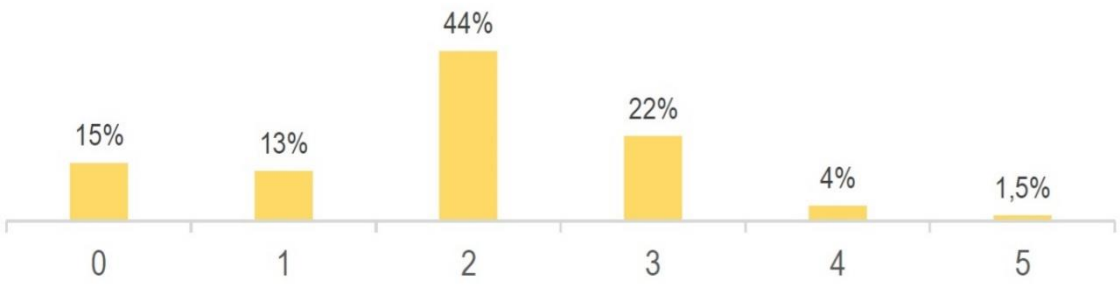

Figure 58. qualification of graduates

57% of responders believe that graduates of construction universities either do not possess BIM technologies or are familiar with the basics of one or more programs and are in need of additional training. Half of them have worked for more than six years.

In addition, half of the responders who reported a relatively low level of graduates planned to train their staff and appreciated the impact of BIM, created all the drawings with the help of information models, which may indirectly indicate the organizations' high expectations of their staff.

20. Are you ready to participate in the development and implementation of educational programs for BIM-competences formation?

1) Yes – 39 (53%)
2) No – 11 (16%)
3) It is hard to answer – 23 (31%)

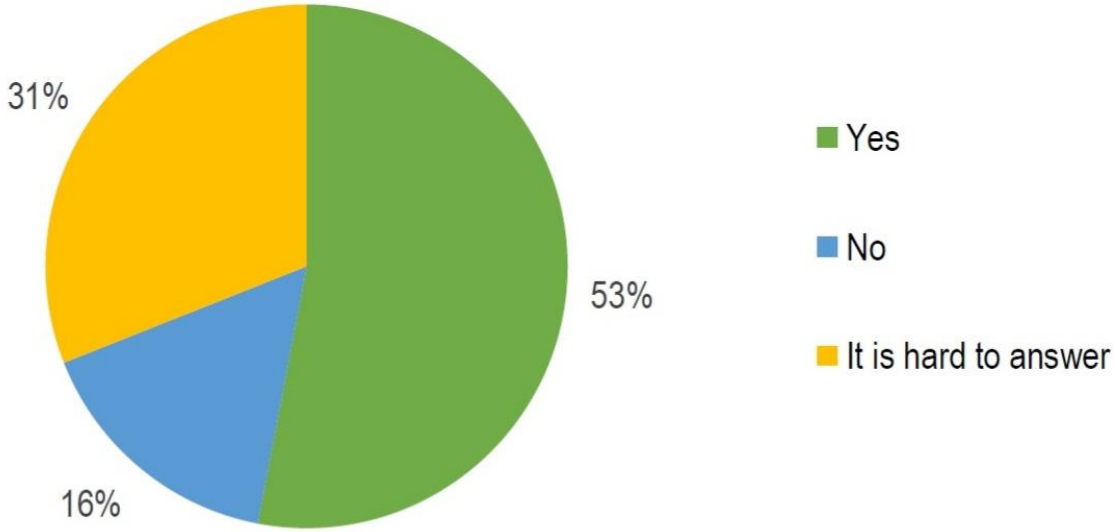

Figure 59. Participation in BIM education

More than half of the respondents are ready to participate in the development and implementation of educational programmes on the formation of BIM-competences. The vast majority of them have more than three years of work experience and assess the qualifications of graduates rather al low. Almost all of them use digital tools, which have been the subject of questions 9 and 10, and are also familiar with the OPEN BIM standards.

21. Which way of collaboration with educational institutes you would prefer? (multiple choice)

1) Guest/open lectures and seminars – 40 (54%)

2) Teaching through study sessions, electives – 20 (27%)
3) Organization of case championships, Olympics, etc. in BIM – 19 (26%)
4) Participation in case championships, Olympiads, etc. BIM as experts – 19 (26%)
5) Mentoring through internships and apprenticeships – 35 (48%)
6) Including of students in the organization's project teams – 28 (38%)
7) Provision of software and training – 7 (9%)

Responders options:

- Getting the practical knowledge
- Looking into all the possibilities
- I am enough qualified for collaboration
- This is a matter for the Personnel Division
- Not ready – 5 (7%)

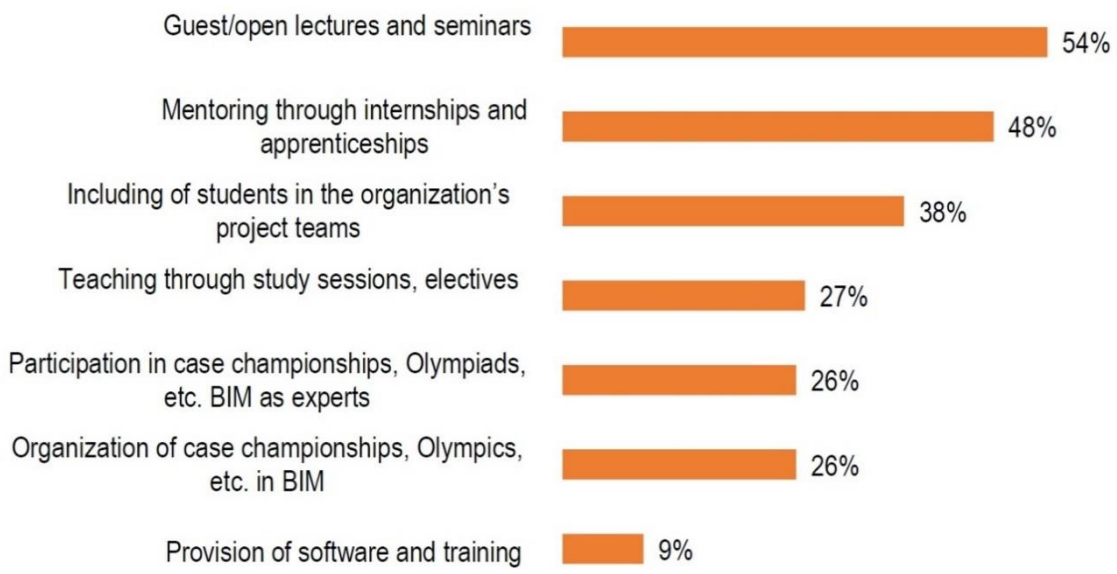

Figure 60. Collaboration with educational institutes

The most frequently chosen forms of cooperation have been traditional - visiting/open lectures and seminars, mentoring through internships and apprenticeships of students. On average, responders chose two to three options.

6 Surveys` conclusion

One hundred and twenty-two respondents from 94 organizations took part in the survey, most of them from Saint Petersburg. Design is also the dominant organization. Among respondents, more than one third of designers, 82% of respondents are specialists under the age of 36, 67% have work experience of not more than 6 years.

More than half of the organizations use BIM to work on their projects. Thirty-nine organizations do not use BIM, which is 41% of the organizations represented. Among these organizations, more than half (59 per cent) are involved in design, but there are no developers or investors at all. Among buildings management organizations, the ratio of BIM technology use to non-use is roughly equal. Developers, general contractors and design and architectural organizations are dominated by organizations using BIM. This feature is particularly evident in architectural design and design.

Organizations not using BIM technology in project work. The reasons for not using BIM are complex and are a combination of external and internal causes, but internal ones, such as a shortage of personnel with the necessary competencies, high cost of technology deployment, selected more respondents, than external causes, such as weak regulatory framework and threat of sanctions on imported software. It is worth noting that for only 14% of the respondents the only reason was the efficient work of the organization and without BIM technologies.

With regard to near-term plans to implement BIM, 16 per cent of the cases were planned, and more than half of the respondents had difficulty answering the question about plans. Among those who do not exactly plan to implement BIM, the vast majority believe that the organization is already effective. In contrast, only 12 per cent of the cases are planned, 39 per cent do not plan, and 48 per cent have difficulty identifying such plans.

Among the circumstances that may facilitate the introduction of BIM, most pointed to the decision of the company’s management as well as the requirement of a regulatory regulator.

The effects that will accompany the introduction of BIM are generally assessed in two ways by respondents, choosing both positive and negative effects. However, 40 per cent are convinced that there are very positive changes. Slightly less than half of the respondents believe that profits will increase in the future, but one third are confident that the team will face greater difficulties.

Organizations using BIM technology in project work. Most of them have completed no more than 30 projects in the last five years, and just under half of the organizations have

implemented no more than five projects using BIM technology. In those organizations that have implemented more than 30 projects, BIM has been used in all projects, most of which are more than five years old.

More than half of the organizations have a portfolio of BIM projects, public buildings, housing, buildings and facilities. Among the software used to develop BIM models, the most common are Autodesk Revit, other programs that use more than a third of respondents - Autodesk Civil 3D, Autodesk Navisworks. The Autodesk Navisworks and Autodesk BIM 360 are mainly used for viewing BIM models. The most used ways of transferring data between software products are export/import through the IFC format and export/import through the DWG format.

Most data exchange between specialists is done using the organization's local network and e-mail. Specialized BIM data exchange platforms are used by just under a quarter of the respondents, and in each case they are shared with other data exchange tools.

With regard to the digital tools used, most respondents use the IFC format, a third use the common data environment, and a quarter use none of the tools suggested. The number of technologies used is related to the number of projects executed by the organization with BIM. Laser scanning technology and the point cloud were not used by more than half of the respondents. Also almost half of the respondents are not familiar and do not use OPEN BIM standards in their work.

More than half of the respondents create all drawings on the basis of the information model. More than a third of the respondents refine the drawings in the CAD complex, almost all of them do not use BIM in all projects. Seventy-two per cent of respondents cited improved performance as the reason for introducing BIM, while only 15 % cited changes in legislation and regulatory requirements as a relevant reason. Thus, the introduction of BIM does have more internal than external causes. The real significance of external causes, such as legislative changes, is now much lower than respondents in organizations where BIM is not implemented (15% versus 65 %). With regard to customer requirements, 28% of non-BIM organizations believe that BIM may lead to the introduction of BIM, but the real percentage is much higher, 53% of which was the reason for the introduction of BIM.

For most respondents, expectations of BIM implementation correspond to or exceed the real impact of technology deployment, indicating a sufficiently high level of satisfaction. The advantages identified by the vast majority of respondents were the improved quality of the project, which was the most common reason for the introduction of BIM, i.e. it can be said that the expectations were met. However, the economic and financial advantages have

been identified by a small number of respondents, so it can be concluded that the introduction of BIM is not justified for the purpose of reducing costs and increasing cost-effectiveness, but for a more convenient and high-quality work on the project, e.g. for participants of the project team.

However, the reasons why BIM is not used by organizations do make it difficult to use BIM. That is, if 55% of the respondents identified the shortage of human resources as the reason for not using BIM, 75% already identified the shortage of human resources as a difficulty in using BIM. Resistance to innovation among staff was also underestimated in non-BIM organizations, with 20% of respondents choosing it as an obstacle and 40% of respondents finding it a real challenge. Organizations do not plan to train specialists in only 8% of cases. The vast majority - 76% of respondents - said that such training was planned. Organizations with, in most cases, more than 30 completed projects and more than 3 years of experience with BIM plan to train their own staff.

Among those who plan external training, i.e. for development programmes, all organizations do not use BIM in all projects, and on average have no more than 10 BIM projects. The competences of graduates of construction universities in the field of BIM-technologies are assessed by specialists rather low - 57% of them consider that graduates of construction universities either do not possess BIM-technologies, or are familiar with the basics of one or several programs and are in great need of training. More than half of the respondents are willing to participate in educational programmes to develop the necessary competencies. Among the possible forms of cooperation with educational organizations, most of the respondents chose traditional formats: open lectures and seminars, mentoring through practice and internship. However, a quarter of the respondents are also ready for the proposed new forms of cooperation in the field of BIM competences.

In general, there are significant differences between organizations in both the assessment of the impact of BIM and in the use of technology. One of the factors influencing the respondents' responses was the level of BIM implementation in the company. For example, the longer the implementation time, the more projects implemented using BIM, the higher the assessment of the effectiveness of these technologies, the more benefits respondents see. However, regardless of the profile of the organization, the respondents note difficulties related to the shortage of staff, the low level of graduates, but most organizations are open to and interested in dialogue with educational institutions, which is certainly a positive tendency.

7 Summary

Last 10-15 years the construction industry is challenged by new technologies and digital transformation. New workflows based on BIM technologies are replacing the old ones. After the first appearance, BIM is developing and reached the point where BIM can be implemented differently among different companies. One way of BIM implementation is Open BIM that standing for an open process and BIM program differentiation. This technology gained big popularity among various BIM users also in Russia wherein 2017 were approved the first documents of BIM regulation.

Open BIM is the way of the collaboration of BIM users based on open standards. Mostly it is used by companies that implement large projects because of cost-effective value. Large projects are highly paid and demand more responsibility from BIM teams. Open BIM offers the flexibility of choice of BIM technology among stakeholders, interoperability and good resources for further asset management. All that improves the quality of the project and even allow the future transformation of BIM models into a digital twin for effective facility operation and management introducing BIM technology into all the phases of the building lifecycle. On the other hand, is cost. Number of BIM software and programs to design, manage and operate, qualified specialists that can supply Open BIM workflow all that increase the cost of the project to implement. The high quality must be highly paid. From this side stands closed BIM that used among smaller firms, deliver enough quality projects and need less money. However, the aspect of BIM workflow choice depends on the cost-effective value and should be responsibly considered before the project was started. Open BIM is an international platform developing by buildingSMART posting updates, guidelines and consulting worldwide.

Open BIM workflow is based on vendor-neutral formats like Industry Foundation Classes (IFC), Building Collaboration Format (BCF), Information Delivery Manual (MDV), CityGML and so on. All these formats are free-to-use. BuildingSMART Finland posted useful guidelines about how to use these standards in work; all explained from architectural part to facility management within 14 COBIM series and 4 Appendixes. The key to Open BIM workflow is a vendor-neutral format. This standard allows the design firms or teams to use their own comfortable-to-use BIM application that meets the required functionality and group demands. The list of BIM programs that supply IFC can be accessed on the buildingSMART website. Project teams choose different apps which original formats cannot be used together in any of the application, here is where IFC format appears. Different BIM project teams of designers, architects, HVAC, MEP (using ArchiCAD, Tekla, MagiCAD, etc.) are

doing their part of the work exchanging IFC format models for collaboration. Designers insert the Architectural model as an IFC reference in Tekla Structures (for example) and develop the Structural model based on it. After that the HVAC and MEP using Structural model IFC reference develop air conditioning system, water and electricity supply. After that, all the models are separately (without references) extracted to the program that can view IFC models, for example, Solibri Model Checker creating a ".smc" merged model for further clash detection and data management. This is the principal scheme of Open BIM workflow.

In 2020 the BIM-ICE project initiated the survey that aimed to describe the situation of BIM and Open BIM in Russia. The BIM-ICE project is funded by CBC and called BIM Integration in Higher and Continuing Education. The project is created in a partnership of Saint-Petersburg State University of Architecture and Civil Engineering and LAB University of Applied Sciences as a leading partner. The project aims to develop BIM and BIM education in the construction industry. To reach the project goal the survey was initiated to understand the current status. According to the survey, Open BIM technology in Russia is used but not as widely as in Finland. The accent of BIM in Russia is still in the closed working format. Nevertheless, Open BIM is used. Big projects use and implement OpenBIM technology in their work at Lakhta Center in Saint-Petersburg. International companies such as YIT and Bonava also use and promote the Open BIM approach in Russia. Moreover, we can see the tendency of market development more and more employers demand the knowledge of different software and experience in work with IFC and Solibri MC. Mostly used BIM applications in Russia are Autodesk Revit, Tekla Structures and Autodesk Navisworks.

To conclude the Open BIM is an innovative and effective technology that develops quality among the construction industry and allows to implement of new technologies such as digital twins, artificial intelligence and the internet of things. This technology is used worldwide and also in the Russian construction market having the potential to widespread. In my opinion, the future of Russian BIM is the open approach. Russia is a big country and will implement a lot of big projects in future across the big territory. Large projects demand high quality this is where Open BIM wins and recommended to use. In future, Russia will use more IFC and reach higher diversity of BIM application and software. To get international experience Russia will tend to attract more international companies and will develop its standards and requirements within the BIM field to supply local construction culture. Also, digital twins will be in demand requiring more and more IFC usage and Russia will have resources to fulfil this demand because the IT sphere is developing rapidly.

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