Digitalisation of the construction planning in Poland

Roadmap for the implementation of the BIM methodology in public procurement

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pwc

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MINISTERSTWO ROZWOJU

Table of Contents

List of figures

List of tables

The text in the orange frame presents additional comments, conclusions and recommendations, which are aimed at facilitating the preparation of the Polish construction market for the adaptation of the BIM methodology primarily in public and indirectly private investments.

THE TEXT IN BOLD ORANGE FONT REFERS TO INFORMATION ESPECIALLY IMPORTANT FOR THE BIM IMPLEMENTATION PROCESS IN POLAND.

I. Roadmap for BIM implementation in Poland – introduction

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1 Roadmap for BIM implementation in Poland – introduction

1.1 Introduction

The purpose of this document is to support the Ministry of Development in developing an integrated BIM strategy for the construction process in public procurement.

The initiative to introduce the BIM methodology in construction is dictated by the concern for the level of effectiveness of construction production, which, according to Eastman's analysis presented later in this chapter [1], does not correspond to the increase in the effectiveness of other branches of the economy despite the introduction of computer techniques. In addition, construction processes are subject to outdated procedures and are based on outdated sets of requirements, which prevents any progress in this area without introducing more radical measures. This Roadmap is an attempt to outline the direction of changes that will allow the construction industry to shift to modern and, at the same time, more effective tracks. It is even more important as many countries in the world, and in the European neighborhood, have already recognized and chose this direction, so it is in the interest of the Polish economy and its competitiveness not to fall behind them.

The general goal of the Roadmap implementation is to achieve by 2025 a level close to the currently required British BIM implementation level, but enriched with many additional elements, presented later in the document.

Development of the integrated methodology is a complex issue due to the requirement to combine investment programming processes within one measure covering the management of the entire life cycle of the facility, from the design stage, through the analytical stage, stage of the construction implementation, to the operation of the facility.

To enable the development of an optimal strategy for the needs of the Polish market, the approaches to BIM implementation in selected countries around the world and the available information on key activities undertaken in this area in Poland were analysed.

An additional condition that can determine the success of this strategy is the right approach to the least predictable element which is the human factor. Technology and business processes can be measured, calculated, analysed and subjected to a series of simulations, while the human factor is the biggest challenge that Polish construction faces in the BIM implementation processes.

The package of changes in conducting construction investments presented in the document is divided into parts that have been visualized so as to be clear to every reader of this document.

In addition, each of these parts is based on strong foundations, both legislative and normative, also taking into account foreign experience. For foundation elements that are not yet available in Poland or have not been adopted from similar processes from abroad, proposals for solutions with their placement on the timeline will be presented for a more complete calculation of the expenditure necessary for their implementation.

However, it should be remembered that we are dealing with the power of a enormous strenght, which includes both activities supporting the development of Polish construction, presented in this document, and generally causes great changes in the entire society, namely with the progress of technological development. This progress will be repeatedly reflected in the proposed strategy aspects as part of the BIM Roadmap for Poland.

The Roadmap proposal presented below should not be understood as a ready solution for the implementation of BIM, but as an indication of the direction necessary for the development of Polish construction [1] in line with

[1] The starting point for the Roadmap is the public sector, but in order to achieve a common platform of agreement of the whole market, the PUSH-PULL approach is recommended (see the chapter about the United Kingdom point 2.1), i.e. the harmony of “pull” and “push” actions.

the trends of evolution of the construction industry taking place in the world. As part of this document, a set of practical steps has been presented to start the process of implementing BIM in Poland.

THE PURPOSE OF DEVELOPMENT OF THIS ROADMAP IS PRIMARILY RAISING AWARENESS OF ALL PARTIES CONCERNED OF WHAT ISSUES LIE AT THE BOTTOM OF THE BIM METHODOLOGY, THEIR LEGISLATIVE[2], NORMATIVE[3], CULTURAL OR SOCIAL BASIS AND HOW AND WHEN THEY CAN BE USED IN THE STRATEGY OF BIM IMPLEMENTATION IN POLAND.

THIS DOCUMENT AIMS TO CREATE GUIDELINES, UNDERSTANDABLE FOR THE CONSTRUCTION MARKET, ON HOW TO WORK WITH THE BIM METHODOLOGY IN A PROFESSIONAL MANNER.

This Roadmap also has the task of opening the field for further studies, based on clear diagrams and understandable relationships between individual elements of the integration methodology, namely BIM.

1.2 Historical background

Improvement of efficiency in the construction sector has often been the subject of scientific research, which aimed to raise awareness on how progress in the field of digital technologies, such as BIM, can improve the functioning of this sector. In 1990s, a researcher from the Technical Research Centre of Finland, Matti Hannus[4], presented graphics (picture below) that illustrates the evolution of efficiency improvement in the construction industry in the world. This graphics is universal and can be used as a starting point also for analyses of the Polish market.

Another researcher, Charles Eastman, in his book “BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors” [1] presents, on the basis of statistical data of the Employment Office in U.S.A. of 2003, the worrying fact, which is not only the lack of increase in the efficiency of construction since the introduction of computer techniques to the industry in the 60s, but rather its decline.

On the other hand, Hannus indicates how the evolution of efficiency is progressing and where reserves should be sought when it comes to improving the functioning of construction processes. His graphic design is based on the concept of the so-called “Island model” of Bo-Christer Bjoerk from the Stockholm Institute of Technology[5].

Therefore, and due to the complex set of implementation steps (see chapter 7), the addressee of the Roadmap is the entire construction market in Poland.

[2] Legislation concerns documents published as laws and regulations, both by the Polish government, and the European Union

[3] Normative aspects (normalization) are products of the Polish Normalization Committee and the international ISO organization

[4] https://www.researchgate.net/profile/Matti_Hannus [Access: May 2020]

[5] https://scholar.google.com/citations?user=ffnrfgQAAAAJ&hl=en [Access: May 2020]

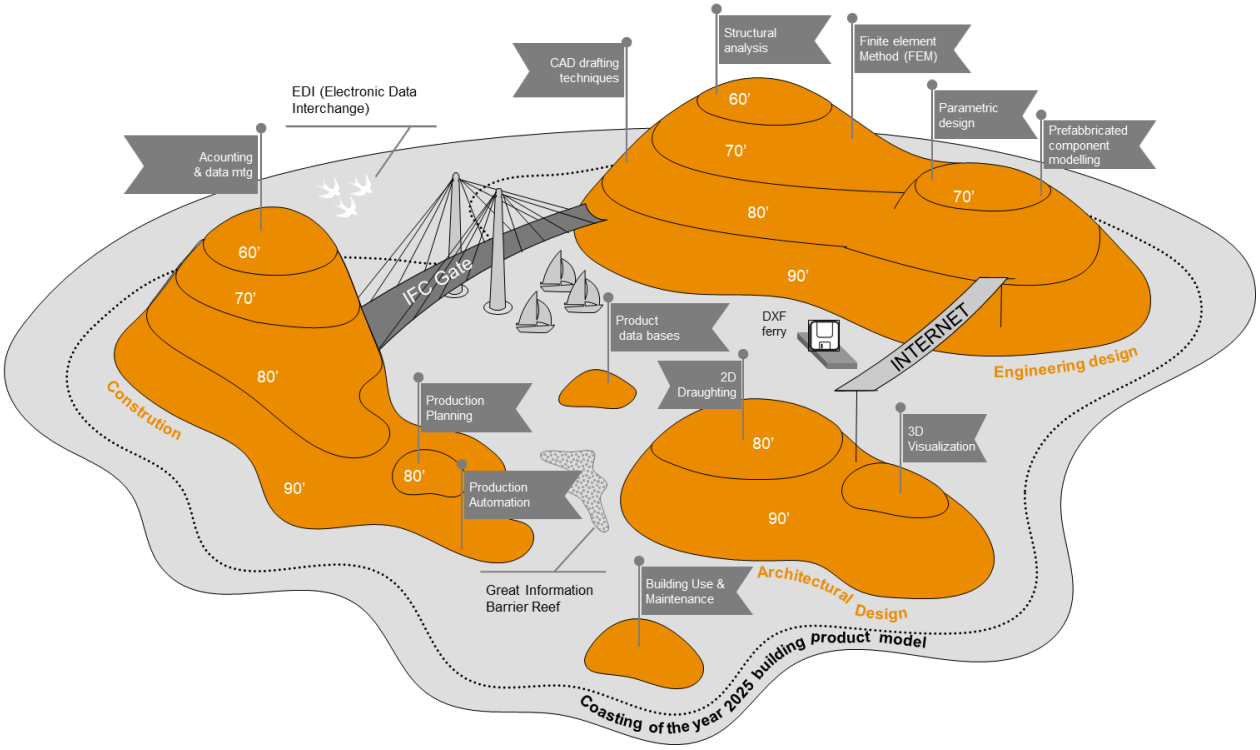

Figure 1: Island Model. Own elaboration based on the Finnish original, reprint [6]

The concept of the “island model” illustrates the lack of knowledge as an ocean, whose waters descend with time and historical progress, showing pieces of land reflecting new, increasingly advanced levels of technological knowledge and automation. The graphics summarize the current milestones in the evolution of building processes and the most important technological inventions since the introduction of computerization in the 1960s.

As can be seen from the graphic design of Hannus, it is not about the particular interests of one group of the investment process, but, above all, about the general evolution of technological awareness and the level of knowledge in order to automate processes and, as a consequence, increase their efficiency. Charles Eastman pointed out in the above-mentioned book that only agriculture and construction have so far not used computerization tools to increase their contribution to the economy.

1.3 BIM in Poland

The current activities in promoting BIM in the Polish market, presented below in this document, are practically not integrated with each other. Some entities, mainly private or organizational institutions (such as PZPB, GUNB, SARP, PZITB, PIIB) have financed or developed many standardization activities, but they are not universal documents for the entire sector because they contain solutions specific to a given undertaking or professional group. Some of them also contain confidentiality or intellectual property clauses, which does not allow for their dissemination in the market.

Therefore, a need arose to create a uniform strategy for implementing BIM in Poland in the form of this Roadmap. This study was prepared at the request of the Ministry of Development (competent for the construction sector) in cooperation with the European Commission.

Developing a national strategy is necessary because it is not possible to adopt solutions or regulations that work successfully in other countries due to different conditions of the Polish market. For example, one of the countries with the most advanced BIM implementation model is Finland. This market is characterized by a high

[6] https://www.researchgate.net/figure/Islands-of-Information-in-the-AEC-industry-after-Hannus-et-al-1995_fig10_232715825 [Access: May 2020 [68]

degree of prefabrication of commercial and residential construction. The difference in the level of automation as well as in the manner and pace of introducing technological changes is currently too great to enable us to quickly catch up and apply similar solutions in Poland.

Another example is the divergence in the concept of economy understood differently by various EU countries. **AND BIM IS, ABOVE ALL, ECONOMY.**

Therefore, the purpose of this document is to outline a clear framework for implementing the BIM methodology so that it can use specific solutions and modify them over the next years to the benefit of the functionality and efficiency of the construction industry in Poland.

First and foremost, ISO standards that have already been developed for BIM and whose Polish versions have already appeared (though not yet in Polish)[7] or are expected in the near future will be helpful. These standards are based primarily on the experience of the United Kingdom, where it was possible to create a strategic scheme that can be helpful in developing individual strategies in other countries, including Poland. The potential use of the British design in the Polish market does not mean that it is to be faithfully copied, but only that we can use the British strategic assumptions to avoid mistakes and errors.

When implementing all strategies, including BIM strategies, the most important thing is to maintain consistency of actions, but also flexibility, providing for the changes required to achieve the basic goals.

[7] Publications of PN-EN ISO from 19650 series, parts 1 and 2 have appeared, but they are still in English. Translation and adaptation to the Polish conditions is anticipated by the Polish Normalization Committee (PKN) to occur at the end of 2020. The consequence is the prevailing lack of Polish equivalents for many English terms regarding BIM. Some Polish translations from this document are aimed to serve as a proposal

II. Analysis of a road to BIM in selected countries

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2 Analysis of a road to BIM in selected countries for the purposes of the BIM strategy in Poland

2.1 United Kingdom

The process of digitizing construction in the United Kingdom is primarily characterized by credibility related to financing implementation activities from public sources, and thus their maturity (activities in the "Pull" category - their equivalent is the self-organization of the construction market, called "Push"). **THIS APPLIES BOTH TO THE DIRECT ACTIVITIES OF THE GOVERNMENT OF THE UNITED KINGDOM AND TO GOVERNMENTAL GRANTS FOR STUDIES PREPARED BY PRIVATE ENTITIES AND NON-GOVERNMENTAL ORGANIZATIONS.**

The result of this is a precise, multi-layered and multi-faceted, complete strategy written over many decades. Even when the implementation of certain points of the strategy goes beyond the assumed time frame, this does not constitute a violation of the chosen direction. An additional strength of the British approach is a solid legal and normative basis for all aspects, whether it is a Roadmap signpost in the form of the so-called Bew and Richards wedge, or columns of the temple of Eynon [8] for the implementation part of the direction adopted in the United Kingdom. And where there was no such foundation, it was created in the process of developing the entire strategy.

It should be noted that the strategy for BIM is a part of the general strategy adopted for the modernization of the entire UK economy, such as Digital Built Britain [2], so it is not a unitary evolution, but a comprehensive process. This approach is also important when creating this BIM Roadmap for the Polish market and therefore is reflected in the rest of the document.

A comprehensive approach is seen by other countries around the world as a good benchmark and used by them both in theoretical and practical preparation of their own BIM implementation strategies. Not all solutions used in the United Kingdom correspond to the specifics of local economies and legislative systems, but nevertheless they are the most complete and consistent direction of BIM evolution of all others functioning in the world. In addition, the British approach is constantly enriched with further aspects, such as Lean for Construction[9], which causes other countries to closely monitor the development of BIM in the UK.

FOR THIS REASON, THE SYSTEM DEVELOPED AND APPLICABLE IN THE UNITED KINGDOM WILL FORM THE BASIS FOR THE PROPOSED APPROACH TO THE PREPARATION AND DEVELOPMENT OF BIM IN POLAND. COMPATIBLE SOLUTIONS HAVE BEEN ADOPTED IN THIS ROADMAP, AND, OTHER ADDITIONAL SOLUTIONS HAVE BEEN PROPOSED FOR ASPECTS NOT REFLECTING THE SPECIFICS OF THE POLISH MARKET. The same approach applies to the use of experience related to the implementation of BIM in all other analysed countries.

Apart from that, it was also proposed to expand the strategy with new aspects resulting from the BIM progress in the world, Polish market specifics and the evolution of the technology itself, i.e. the factor with the most dynamic growth rate. For all these aspects, a technological foundation was introduced for repeatability of the processes, important for the adaptation of the system in society.

[8] These are visual provisions of the British strategy. These graphics can be found in the presentation for the Ministry of Development dated 19 March 2020, they are also available on the portal of the Ministry and in another part of this strategy, entitled "History of BIM implementation in selected member states of the European Union - material supplementary to meetings with the stakeholder"
[9] https://en.wikipedia.org/wiki/Lean_construction [Access: May 2020]

2.2 Spain

In response to EU Directive No. 2014/24/EU[10], the Spanish Ministry of Infrastructure appointed a commission in July 2015 to implement the BIM methodology in Spain, called esBIM[11], chaired by the Minister of Infrastructure. A date was set for the implementation of BIM in public investments for March 2018, as well as for its mandatory use in public tenders for large-size buildings for December 2018, and for infrastructural sites for July 2019.

To support implementation processes in Spain, the first two parts of the BIM ISO 19650 standards were published in July 2019. The standards became the ISO standard at the end of 2018, and in Europe they began to be published from January 2019. These standards are based on the experience resulting from the British documents based on the principle that information is first structured and then the standard is set after checking its usefulness in practice, after a specified period of time.

The work on the development of the strategy was actively joined by the so-called Spanish chapter (i.e. a branch) of the international organization buildingSMART International (bSI)[12], established in 2012. In 2014, the Spanish chapter published BIM standards in Spanish under the name UBIM[13], which were adapted from the Finnish coBIM (Common BIM Requirements)[14], consisting of a series of 13 documents for various scopes of the BIM methodology.

In November 2019, the secretary of the Spanish chapter bSI Sergio Muñoz Gómez, who is also the president of the Spanish Standardization Committee BIM – UNE CT41/SC13, published an article on the dbeinstitute.org portal [15] [3] summarizing the standardization for BIM in Spain, claiming that only an ISO form for the IFC format (ISO 16739) has practical meaning in public investments, being their required condition. Observers of public tenders for esBIM state in cyclical reports[16] that the application of the integrated methodology in the first three years from the commission's findings is not yet satisfactory (graphics from the above-mentioned article, entitled "Requirements for standards in public tenders in Spain" are presented below). However, in the same article, Muñoz expressed the hope that Spanish construction entities would quickly adopt the published ISO standards for BIM 19650 series.

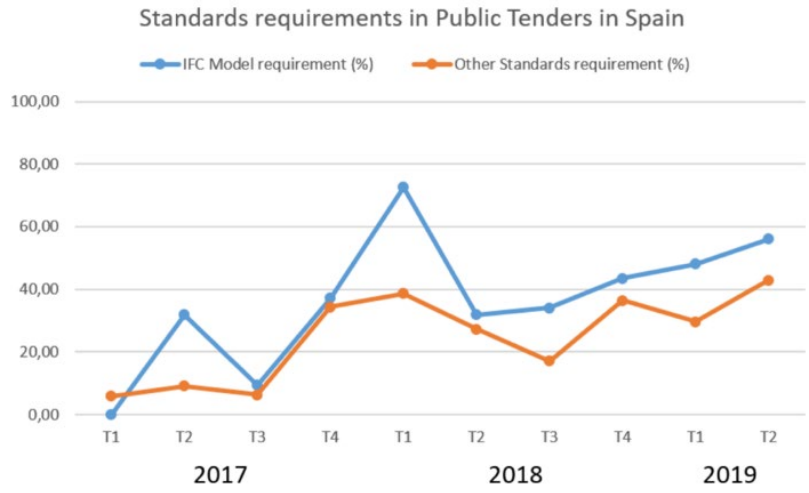


Figure 2: Requirements of standards in public investments in Spain (after the introduction of an obligation to use BIM).[17]

[10] https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32014L0024&from=PL [Access: May 2020] [121]
[11] https://www.esbim.es/en/ [Access: May 2020]
[12] https://en.wikipedia.org/wiki/BuildingSMART [Access: May 2020]
[13] https://www.buildingsmart.es/bim/gu%C3%ADas-ubim/ [Access: May 2020]
[14] https://buildingsmart.fi/en/common-bim-requirements-2012/ [Access: May 2020]
[15] https://www.dbei.org/news/impact-of-bim-iso-standards-in-spain/ [Access: May 2020]
[16] https://www.esbim.es/observatorio/ [Access: May 2020]
[17] https://www.dbei.org/news/impact-of-bim-iso-standards-in-spain/ [Access: May 2020] [69]

Spain is also developing parallel development strategies for other industries. One example is the strategic document of the Ministry of Science, Innovation and Universities of 2019 called “Spanish RDI Strategy in Artificial Intelligence” [4]. Among other things, this study talks about Smart Cities, economics, industry 4.0, environmental impact, education and health aspects, so it analyses technological development for the whole society. Another strategic document is the study of the Ministry of Development, “Innovation Plan for Transport and Infrastructures 2018-2020” [5] of February 2018. The general Spanish strategic document for development is the study entitled “Spanish Science and Technology and Innovation Strategy 2013-2020” [6] of the Ministry of Economy and Competitiveness of 2012.

AS CAN BE SEEN, DEVELOPMENT STRATEGIES IN ALL ANALYSED COUNTRIES CONCERN THE WHOLE ECONOMY, AND NOT ONLY THEIR SELECTED ASPECTS, but also in the case of Spain, the strategy for the BIM methodology itself is not clearly articulated, consisting mainly of recommendations in speeches and media articles.

2.3 The Czech Republic

A few years ago, Czech government agencies attempted to develop comprehensive development directions for the Czech Republic.

The main strategic document is the study called “Strategic Framework Czech Republic 2030” [7], developed in 2017 by the Government Office of the Czech Republic, the Government Council for Sustainable Development (a permanent advisory body initiating and coordinating the government in the field of sustainable development, strategic management and long-term priorities of the state) with the support of EU funds. The document covers and describes the required strategic actions in six main areas:

- People and society;
- Economics;
- Resistant ecosystems;
- Regions and municipal authorities;
- Global development;
- Good governance;

In addition to the general strategy, several individual strategic documents were also developed, including:

- Transport system development strategy - Action Plan for the Deployment of Intelligent Transport Systems (ITS) in the Czech Republic until 2020 (with the Prospect of 2050) - the Ministry of Transport 2015 [8];
- Geoinformation unification strategy, called GeoInfoStrategy - The Strategy for the Development of the Infrastructure for Spatial Information in the Czech Republic - Faculty of Applied Sciences of the University of West Bohemia 2016 [9];
- BIM Strategy - BIM Implementation Strategy in the Czech Republic - Ministry of Industry and Trade 2017 [10];

While the first two strategies above are documents supported by appropriate standards, templates of procedures and practical guidelines, the BIM study does not yet contain a specific direction for the development of BIM implementation in the Czech Republic, but only a list of references to British documents and recommendations for the Czech market. There are no Lean elements for the management of design and construction processes that are already a part of Lean Construction in the world. In addition, a contractual obligation to develop a BIM Execution Plan (BEP) was imposed, for which better solutions already exist in Poland, e.g. the division of the Plan into two parts (general - pre-contractual and practical - contractual). The other two requirements, enabling the appointing party in the Czech Republic to obtain full and transparent

control over the process, relate to the supply of models in the IFC[18] open format and the application of the CDE digital environment[19].

The BIM strategy in the Czech Republic introduces a wide scope of integrated methodology, such as Facility Management or Geoinformation (GIS) mentioned before. This document correctly recognizes all (except Lean) fields of activity required for BIM implementation.

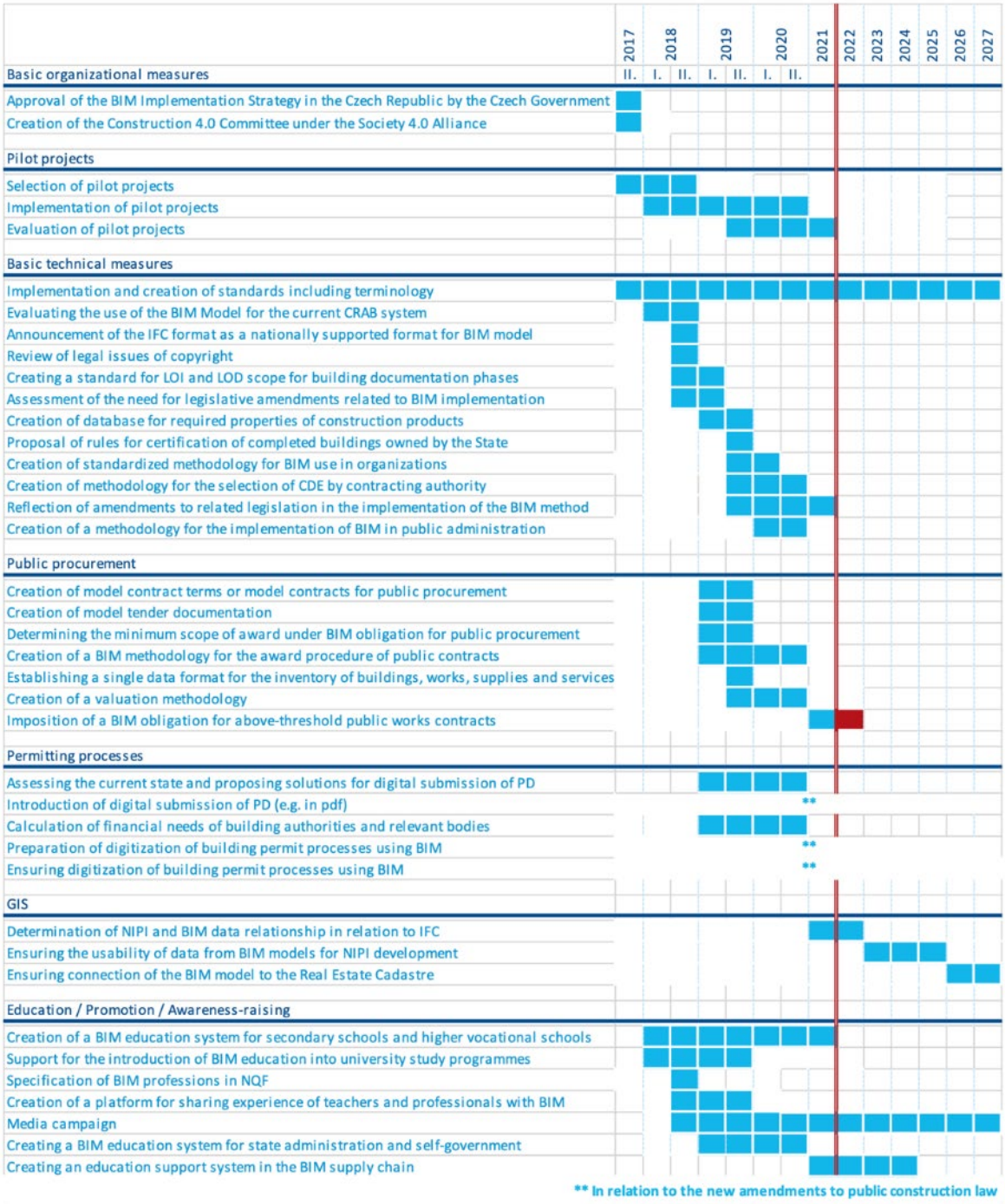
Another important point is the clear definition of intellectual property in terms of personal rights and use. In the Polish Act on Copyright and Neighbouring Rights[20], there is also such a definition, but it is not always respected when carrying out construction investments in Poland. The necessity of implementing pilot projects (which, for example, in Germany form the basis of the BIM strategy) was also properly identified recommending pilot projects from the first stages of BIM implementation, in line with the presented strategy.

ANOTHER ADVANTAGE OF THE CZECH BIM STRATEGY IS OBLIGATORY USE OF BIM IN PUBLIC INVESTMENTS ABOVE A CERTAIN INVESTMENT COST THRESHOLD. THE DEADLINE SET FOR THE BIM OBLIGATION IN THE CZECH REPUBLIC IS 2022, I.E. 5 YEARS FROM THE PUBLICATION OF THE STRATEGIC DOCUMENT IN 2017.

The visual record of the recommendations for the Czech strategy from the document in question is presented in the figure below:

[18] The open format of information exchange developed and updated since 1995 by the buidlingSMART International organization. The full definition is in the Glossary which forms another part of this project.
[19] Digital environment of information management in the integrated investment process. Definition in the Glossary. Also, see further on, point 5.5.2.6
[20] See point 6.8.1

6.1 Schedule of recommended measures



40 / 51

Figure 3: A record of the Czech strategy of BIM implementation along the timeline. [11]

2.4 Other European countries

2.4.1 Estonia

One of the countries which is most dynamically developing in Europe, namely Estonia, is a good example of what the evolution of social dynamics can look like when there is social consensus. Representatives of Estonia, together with representatives of the Czech Republic and Denmark, are currently cooperating on the implementation of one of the most advanced integrated methodologies for classification systems. Estonia has also introduced distributed processing technology for many types of public services (see point 5.6.2.3).

HENCE THE ANALYSIS OF PATTERNS FROM ABROAD SHOULD ALSO TAKE IN ACCOUNT THE SOCIAL CONDITIONS. ONE SHOULD NOT TO BREAK FROM THEM IN THE MAPPING OF THESE COUNTRIES' ACHIEVEMENTS ON THE POLISH MARKET.

2.4.2 Finland

Finland has extensive experience in using BIM and developing software for creating, analysing and managing BIM processes. It is also one of the pioneers of introducing Lean procedure methods to the construction industry with an emphasis on visual process management, reduction of process losses and automation. All entities are involved in the BIM implementation process in Finland, from government agencies, to municipalities, to academic and business environments. The market receives additional support from Lean Construction Institute Finland in the form of active promotional activities and publications, such as periodic reports. Particular attention is paid to a smooth transition from design to fabrication.

Automation and robotics in the Finnish construction sector translate into prefabrication, which reaches 75% for housing investments (data from 2010 [11]). This is due to the fact that Finland began the implementation of BIM at the end of the last century, and practically introduced an integrated methodology in the first decade of the 21st century.

In Finland, a set of BIM requirements called coBIM (Common BIM Requirements) was developed, which is a series of 13 standards systems, adapted by some countries, e.g. Spain, for their own implementation needs.

This does not mean, however, that there are no Finnish strategic documents. One example is the strategy for the transport sector of the Finnish Transport Infrastructure Agency (FTIA) from 2019 called "Digitalization and BIM at Finnish Transport Infrastructure Agency" [12]. This document contains many directional indications, such as the recommendation for Open BIM:

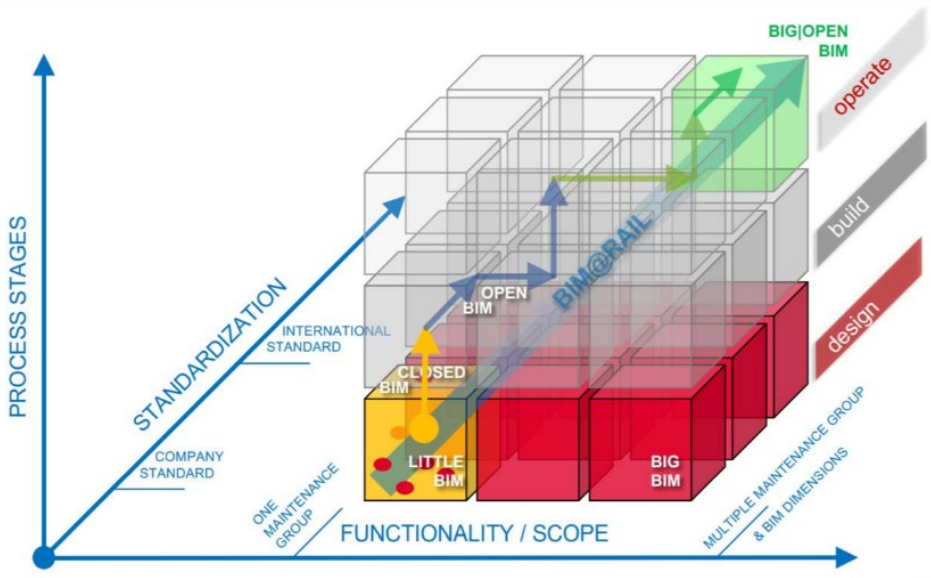


Figure 4: The purpose of the Finnish infra strategy: Big Open BIM. [13]

Geospatial is another strong integrated system in Finland. In 2019, the Geoportti.fi portal was launched, containing SDI (Spatial Data Infrastructure) geoinformation resources for GIS data and metadata. Work on the portal was initiated by a project of the Ministry of Agriculture and Forestry, which led to a report on spatial information policy[21].

2.4.3 Germany

In Germany, there is a set of strategies for various branches of the economy, e.g. “Implementierung von Building Information Modeling (BIM) im Vorstandsressort Infrastruktur der Deutschen Bahn AG” [13] for rail infrastructure, developed by the management of German railways. It is a coherent document, also specifying a timeline for the described activities. The German BIM strategy for railway infrastructure is well developed, despite the lack of many components that ensure the full implementation of the integrated methodology.

BIM standardization in Germany is primarily based on recording the functioning operating formats, preferably in ISO documents, or at least in a defined form. The further path to the standard covers standardized steps for obtaining the status of a national DIN standard. The figure below from the 2017 implementation report illustrates this standardization process for version 5 of the IFC format, which already contains structural units (so-called IFC entities) for use in infrastructure projects. As part of buildingSMART, Germany started a project to translate the names of IFC units so far written in English[22] into German to better serve the local market.

Figure 5: German way to national standards. [14]

The German BIM implementation strategy is based on three phases of the so-called Stufenplan (a milestone plan) developed by the Ministry of Transport and Digital Infrastructure (BMVI) in 2015 [15].

[21] https://mmm.fi/en/land-surveying-and-spatial-information/developing-the-spatial-data-infrastructure [Access: May 2020]
[22] The whole hierarchical structure of IFC is written in English as an international standard

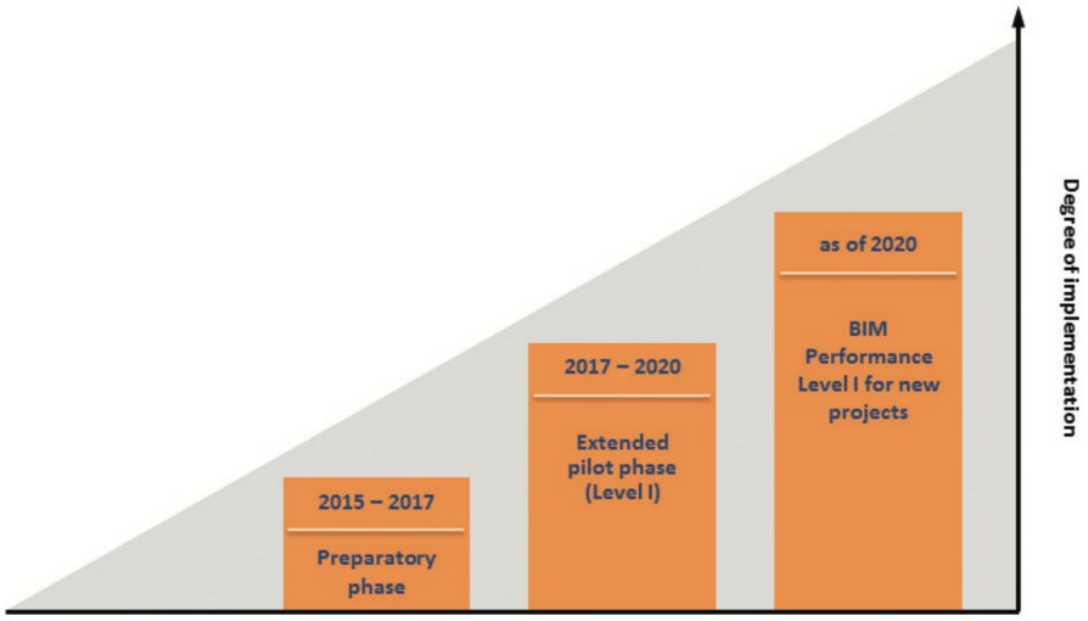


Figure 6: Stage plan of the German strategy of implementation BIM. [16]

The above figure presents all the stages of Stufenplan:

- the first stage is active preparation, including pilot projects, standardization, education and further learning, developing a BIM course, clarifying legal issues (2015-2017);
- the second stage is a practical application for pilot projects - it assumes the extension of existing practices, project palettes, collection and evaluation of BIM experiences (2017-2020);
- the third is the establishment of BIM level 1 as the standard for all subsequent projects.

Level 1 of BIM does not refer to the British wedge standard, developed by Bew and Richards, but it is an own German study, the specification of which is included in chapter 4 of the Stufenplan strategy document. Level 1 of BIM includes, in the milestone plan for Germany, the following elements:

- Data (EIR – appointing parfty's requirements; industry models in 3D format and any 2D models derived from the models, ensuring compatibility of models with EIR; an option for the appointing party to require open formats; ensuring availability of both necessary hardware and software; entering BIM in contract documents);
- Processes (obligation of the appointing party or its representative to create a BIM Execution Plan - BEP; obligation to establish a digital investment procedure environment - CDE; recommendation to avoid overproduction of project data due to the future need to administer them in the operation of facilities; establishment of principles of cooperation and partnership in the investment process; establishment by the appointing party of the rules for making decisions by way of discussion);
- Skills (providing all participants in the process with the ability to cooperate and other features related to the BIM methodology; demonstrating BIM experience and skills on both the lead appointed party's and the appointing party's side);

A report published in 2017 by BMVI [14] on the status of BIM implementation already contains a summary of previous experience from pilot projects in the field of infrastructure, with an analysis of the set goals and ways of using BIM in the implementation of these projects, carried out individually for each of these projects.

The following figure from the above-mentioned report presents the implementation schedule of the milestone plan for new pilot projects, mainly infrastructure projects, from all over Germany.

A – Support for new pilot projects and investor consultancy in the Laender

B – Clarification of legal issues and aspects of contract preparation

C – Developing BIM scenarios for 2020

D – Database concepts

E – Development of guidelines, templates and information materials

F – Reports and public relations

Figure 7: Implementation schedule from an independent report, ordered by BMVI (2017). [14]

As can be seen in the examples of these studies, the German approach to the implementation of BIM is consistent, stable and based on solid normative foundations. In addition, it is regularly monitored by independent reports, such as the document entitled “Wissenschaftliche Begleitung der BMVI Pilotprojekte zur Anwendung von BIM im Infrastrukturbau” commissioned by BMVI to external experts and published in April 2018 (Scientific support of BMVI pilot projects for the use of BIM in infrastructure construction) [16]. Recommendations for each of the participants in this project have the following format: “data - processes - technology - qualifications”, and the general recommendation for further strategies lists the scope of research and development, as well as normalization and standardization. The standards from the ISO 19650 series are already a standard for these and future projects, and the effects of implementation are checked on an ongoing basis in pending investments as part of detailed analyses.

Such an approach structured and consistent, although not the fastest, limits the possibility of making mistakes. The main direction is:

CONVERGENCE (2020) ➔DIGITAL COMPETENCE (2025) ➔DIGITAL TRANSFORMATION

And although the record of this evolution does not come from the national German BIM strategy, but from the BIM implementation document for Deutsche Bahn [13], mentioned in the introduction to the chapter, these are nevertheless appropriate steps of progress for every type of technological development.

2.5 Other non-European countries

2.5.1 Singapore

Singapore is one of the most advanced Asian countries in terms of BIM adaptation. The BIM Steering Committee[23], established by the Building and Construction Authority (BCA)[24] to develop the instructions, began operating in 2011, and the strategic document called "Singapore BIM Guide" was developed by BSC [17].

This document divides the implementation of BIM into three scopes:

- **Results, i.e. "WHAT"** - what is to be produced: model elements and attributes, representations of geometrical and non-geometrical properties, additional requirements for information from models - BIM added value, such as environmental simulations, lighting, sunlight and shading, model schedules and cost calculations according to the bill of quantities. Other elements include the definition of the design stages and their content, as well as the authors and users of the models;
- **Processes, i.e. "HOW"** – modelling and cooperation procedures: process steps, instructions for modelling and generating information for individual industries, including a reference to templates prepared by the Steering Committee for electronic delivery of work results, description of procedures of coordination of multi-branch models, establishment of their common geometrical origin and geographical orientation, structural division with management of subsequent changes. This scope also includes a matrix of cooperation between participants in subsequent stages of the project, as well as a description of the publication requirements for various types of documents, with a list of required formats, taking into account their usefulness in the operational stage and quality assurance. An additional value of this strategy for the process stage is the description of the procedural steps for the "build" and "design and build" contracts, unfortunately not including IPD contracts[25];
- **Personnel / professionals, i.e. "WHO"** – process participants: their roles in BIM processes and related responsibilities (although only the roles of the BIM manager and coordinators on the consultant's and general contractor's side are listed and described).

In addition, the Singapore document describes the features of the BIM Execution Plan (BEP) as a mandatory element of processes, and also defines the document regulating the results of project activities called "BIM Objective and Responsibility Matrix".

The strategy contains several important elements, such as templates for definitions and the definition of a different distribution of financial compensation compared to processes not carried out in BIM, which is consistent with the increased workload in the first stages of investment processes in the BIM methodology.

Project Stage	% change from non-BIM to BIM payment
Preliminary Design	+2.5
Planning Approval	0
Design Development	+2.5
Tender and Award	0
DESIGN STAGES *	**+5**
Construction Administration	-5
Post construction	0
CONSTRUCTION STAGES*	**-5**
Percentage change in total fees	0

* refers to cumulative percentage fees

Figure 8: Changes in the system of distribution of fees of the Integrated Team. [17]

[23] https://bimsg.org/2012/02/01/about-singapore-bim-steering-committee/ [Access: May 2020]
[24] https://en.wikipedia.org/wiki/Building_and_Construction_Authority [Access: May 2020]
[25] IPD (Integrated Project Delivery) contracts are discussed in chapter 5.3

In addition, the strategy document contains attachments that define templates and standards, mainly for use in specific projects, but also general recommendations and practical tips. The document itself is a guideline for BIM and requires further clarifying documents. The Singapore strategy was also indicated in the Building and Construction Authority (Cheng Tai Fatt) presentation entitled “Singapore BIM Roadmap” in 2013 [18]. The document lists 5 strategic steps for BIM:

- The leading role of the public sector;
- Formal approval, promotion of successful investments conducted in BIM methodology;
- Elimination of obstacles;
- Building skills and development of BIM scope;
- Motivation of pioneers to implement BIM.

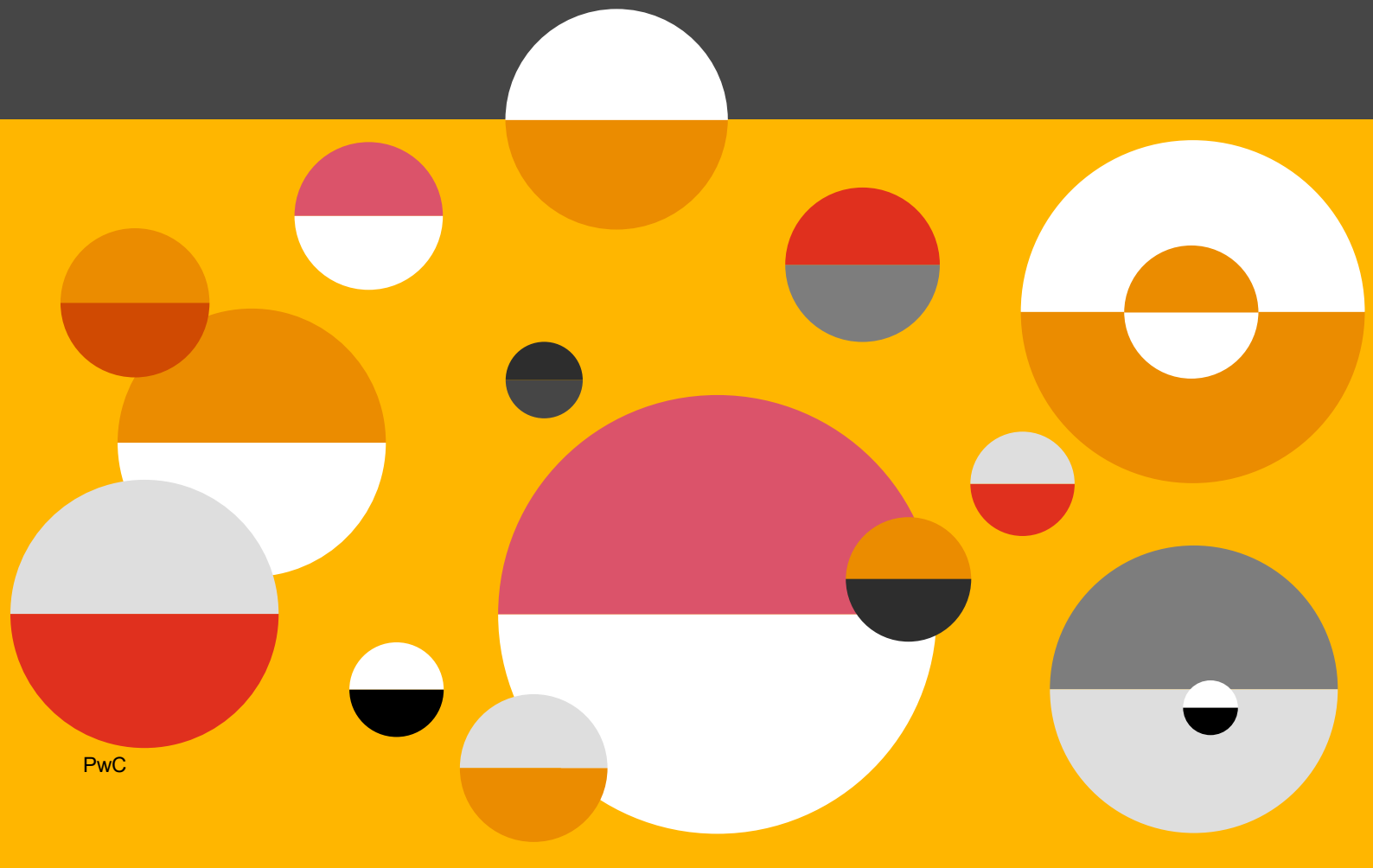
The presentation also includes suggestions of BIM obligatory for the architecture of new large-size investments above 20,000 m^2 (from July 2013), industry studies for new large-size investments from 20,000 m^2 (from July 2014) and for joint industries for new large-size investments with an area larger than 5,000 m^2 – the goal is to achieve a level of 80% of use of BIM in such investments (from July 2015).

Summing up the analysis of the BIM implementation strategy in various countries around the world, it should be emphasized that, with the exception of the United Kingdom and partly Germany and Singapore (but many elements are missing here), none of the analysed countries presented a consistent, complete and visually-clear direction for an integrated methodology for its market. National strategies for, for example, transport systems or geospatial information, look much better in this context.

Table 1. Elements from other countries for the Polish Roadmap

Item	Country	Elements of the strategy implemented in the Roadmap for Poland
1	United Kingdom	Push-pull strategy, high and understandable degree of graphic representation of the Roadmap, initiative to build a digital country model based on related digital twins, focus on open formats in further stages of BIM implementation, public financing of implementation works (government grants), initiation of BIM standardization for ISO standards in PAS and BS standards, basing the Polish road to BIM at the British Level 2, enriched with the use of digital twins, distributed ledger technologies, Lean methodology and the sustainability aspect
2	Spain	Different implementation dates for BIM mandate depending on the type of project
3	Czech Republic	An approach based on the practical use of BIM in pilot projects from the beginning of the implementation process. Establishing a Steering Committee as a body gathering the top-down BIM decision-making in Poland, with the minister for development as a leader and selected advisors, as indicated by Czech experts (based on their experience)
4	Estonia	A comprehensive process of digitization of public services, the use of distributed processing technology for data security
5	Finland	A comprehensive process of digitization of construction, the use of open formats in data exchange, a high degree of prefabrication in construction
6	Germany	Clearly written BIM implementation strategy based on several stages and early pilot projects, introduction of the concept of convergence to unify the goals of participants in construction process
7	Singapore	Public leadership for the process of BIM implementation, a high degree of design for large-scale fabrication and prefabrication, BIM obligation assigned to industries and types of investments, recommendation of regrouping project costs into early investment phases, motivation of BIM pioneers

III. Poland – the starting point for BIM – strategy development



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3 Poland – the starting point for BIM – strategy development

3.1 An analysis of the existing documents and strategic initiatives

In recent years, several surveys have been conducted in Poland, mainly by software producers, aimed at determining the level of BIM preparation among their target groups. In addition, several documents were published to harmonize the process of introducing BIM to the Polish market. The questionnaire, being a part of this project, as indicated in point 03.1.4, also serves research purposes to create strategic directions for the implementation of BIM.

3.1.1 General assumptions of the BIM implementation process in the implementation of public works contracts in Poland (SARP/PZITB/GUNB) (2015)

The document prepared by the Association of Polish Architects (SARP), Polish Association of Construction Engineers and Technicians (PZITB) and the Main Building Supervision Authority (GUNB) [19] of March 2015 contains, in addition to general recommendations, a number of applications that are still valid despite the expiry of 5 years from the development of the study. The document also contains market statistical data helpful in implementation analyses.

The SARP/PZITP/GUNB study suggests linking implementation processes with the use of funds from operational innovation support programmes, such as the Intelligent Development Operational Program (2014-2020) and the Digital Poland Operational Program (2014-2020). The document proposes to combine this course of action with the procedure of changes in the text of the Act on Public Procurement Law. This suggestion has an integrative nature, conducive to cooperation in introducing the new BIM methodology into the Polish economy.

The most important part of the document is the visualization of the strategy of the BIM implementation process in public investments in Poland, divided into 5 factors:

- The establishment of an implementation-coordination centre of BIM;
- Development of standards and norms;
- Development of draft legislative changes;
- Substantive supervision of organizational changes;
- Supervision of pilot projects.

The record of the degrees of implementation processes' maturity is as follows:

EDUCATION ➔ COOPERATION ➔ IMPLEMENTATION

The strategy itself has been divided into stages (but without giving indicative dates, as in the case of Germany):

- Traditional practice (present status);
- Site modelling;
- Co-operation and interoperability;

- Network integration.

This is a record of BIM levels (0-1-2-3) from the Bew-Richards wedge[26] from the United Kingdom, which confirms how strong the British idea of visualizing the BIM evolution process has become. An interesting thesis, not expressed so far, set out in the document is also the evolution of the threat to implementation processes written down as a consequence of inappropriate actions:

PARTICULARISM ➔ CONFORMISM ➔ COSTS

Another valuable feature of the document is the precise and proper analysis of challenges and obstacles to the implementation of BIM in Poland. The upcoming changes are more or less openly signalled, such as procedural and financial transparency, continuous learning, economically-motivated need to move away from antagonisms resulting from mutual resentment of individual groups of participants in building processes, or to move away from the role of the designer in favour of cooperative decision-making.

For the composition of the elements of this strategic study, the most important supporting point is the need to introduce such changes in the standardization codification to enable **verification of the investment effectiveness**: point 2.b Tasks (BIM implementation and coordination centre).

3.1.2 KPMG/Arup report (2016)

The KPMG report of 2016 prepared in cooperation with Arup, at the request of the Ministry of Infrastructure and Construction [20] was an attempt to examine the Polish market in terms of preparation for investment in the BIM methodology. Its results have brought about many widely recognized insights into the condition of the Polish construction industry, but no conclusions can be drawn from them as to the composition of the current BIM Roadmap for Poland, or for the BIM implementation strategy in this Roadmap.

3.1.3 PIIB strategic document (2019)

In December 2019, a document was published entitled: “Strategy of the Polish Chamber of Civil Engineers (PIIB) within the scope of BIM implementation, the place and role of the Chamber in this process and indicating ways of implementing this strategy” [21]. The study details a few key areas for further action:

- Digitization of the construction process;
- Standardization;
- Legislation;
- BIM popularization.

The main goal of the PIIB strategy is to protect the interests of its members (for which the Chamber was established) and the active participation of the Chamber in BIM implementation activities in Poland. The document also assumes the cooperation of all stakeholders dealing with BIM, which is a supported postulate.

The study also includes other conclusions presented by the Chamber in various periods of research on BIM during the last 4 years:

- Developing a government programme for implementing the BIM methodology and state support for small and medium-sized enterprises in the field of financial assistance for the implementation of BIM;
- The postulate of non-obligatory BIM for each public contract;
- The postulate for gradual implementation of BIM, starting from large investments;
- The postulate to start the implementation of BIM in public entities and designers;

[26] Bew-Richards wedge, graphically presenting the British strategy of BIM implementation, is mentioned in the following chapters of the study

- The postulate of rephrasing of Art. 10e of the Act on PPL regarding the availability and access to tools for electronic modelling of construction data.

The strategy of action defined by PIIB assumes activities in four selected areas:

A. Tasks in the field of digitization of construction relate to such aspects as identification of obstacles in the implementation of BIM, proposals of ways to eliminate all these obstacles and specific actions of the Chamber going in this direction.

B. Tasks in the area of standardization include a list of activities for:
   - construction agreements and contracts;
   - requirements for BIM;
   - model details and accuracy;
   - data formats;
   - model elements and blocks;

C. Tasks in the area of legislation encompass:
   - provisions regarding administrative proceedings;
   - provisions regarding the construction law and other laws related to it;
   - public procurement provisions;
   - intellectual property provisions;
   - provisions regarding civil and criminal court proceedings;
   - provisions regarding BIM education and certification;

D. Tasks in the area of BIM popularization encompass the following postulates:
   - implementation of the basic assumptions of the PIIB social communication strategy;
   - BIM training;
   - BIM events;
   - publications as sources of information on BIM;
   - BIM software;
   - BIM competitions.

The list of postulates from the PIIB strategic document is a set of recommendations that are structured and recorded in an appropriate way, it may also be included in this Roadmap, excluding the elements for which regulations already exist (e.g. Act on the Protection of Copyright and Neighbouring Rights[27] [22]), and appropriate actions are taken (publications on BIM in professional press and BIM workshops and training sessions conducted by various organizations and associations).

THE PIIB DOCUMENT MAY BE CONSIDERED A SUPPLEMENTARY STUDY TO THIS STRATEGIC DOCUMENT. However, it is postulated to change the wording “BIM levels” from the last page of the glossary to “BIM dimensions”, so that there is no conflict with the names of the British BIM levels for the Bew-Richards wedge used in various documents prepared as part of this project. **There may also be no equation between the open BIM and file browsers in native formats.**

3.1.4 Survey for the Ministry of Development (2020)

The latest survey conducted in February 2020 among various representatives of the construction industry in Poland for the needs of this project at the order of the Ministry of Development, the results of which were published in the document entitled “Recommendations and conclusions - consultations with stakeholders”, showed several trends. Based on the 533 submitted sets of responses, there is a better understanding of the

[27] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU19940240083/U/D19940083Lj.pdf [Access: May 2020]

BIM methodology and its impact on improving both the quality of projects and communication between participants in construction processes.

On the other hand, the survey results showed many contradictory demands regarding, e.g. obligatory nature of BIM in the Polish market or the use of produced information in all investment stages. A large percentage of respondents, even from among participants who have already started introducing BIM (about 2/3 of respondents in this group), are afraid of the negative economic results of implementing the BIM methodology for their activities. There is also a group of respondents not planning to implement BIM.

Another characteristic feature of the survey results is the discrepancy in the expected benefits of BIM in the case of responses from different types of participants in construction processes, which indicates that not everyone speaks the same language when it comes to the new methodology. **THEREFORE, WE SHOULD NOT EXPECT MUTUAL UNDERSTANDING IN THE NEAR FUTURE WITH REGARD TO THE CONDUCT OF THE INTEGRATED PROCESS (E.G. FOR PILOT PROJECTS) AND, WHAT FOLLOWS FROM THAT, FULL COOPERATION IN GOING IN THE SAME DIRECTION.** Hence, the greater demand for studies that will coordinate all stakeholders expectations and bring order to the implementation of BIM in Polish construction industry, because this is also what its digitization comes down to.

Another requirement that most respondents agreed on is a need for education. **HOWEVER, SINCE EDUCATION REGARDING NEW PROCESSES IS OBVIOUS, IT WILL NOT BE LISTED AS A SEPARATE POINT OF THE ROADMAP, BUT IT WILL BE AN ELEMENT SUPPORTING EACH ASPECT OF THE BIM METHODOLOGY,** in particular in technological terms, but also management of the human factor, environmental requirements, data security or classification systems.

3.1.5 Initiative of the Chamber of Architects of the Republic of Poland (2020)

Recently, IARP approached the Ministry of Development with an initiative to develop a coherent strategy for the digitization of the investment process. According to the Chamber's declaration, a working group will be established with the participation of IARP and PIIB under the leadership of GUNB and the patronage of MR.

3.1.6 BIM Handbook by EU BIM Task Group (2017)

„Handbook for the introduction of Building Information Modelling by the European Public Sector" - document outlining the BIM implementation strategy. The document has been developed by the EU BIM Task Group in the language versions of the member countries[28]. The document contains a.o. the general strategy outlines and the individual case studies from different states to illustrate the expected efficiency improvement in the construction sector of the European Union.

3.2 Steps to prepare a Roadmap

In the process of preparation of the strategy of BIM implementation in the Polish market, a similar method was proposed of creating its elements and in the British strategy (Digital Plan of Work → Roadmap → 8 columns of the Eynon's implementation system)[29], however, in order to ensure higher transparency, it was reversed. This facilitated the synthesis of elements and placing their components on the timeline.

The following steps have been adopted for further work stages:

- Defining boundary conditions necessary for full implementation of the Roadmap, resulting from the current condition of the Polish market and directions of global BIM development;
- Defining the components of the entire integrated process environment in construction;
- Combination of these parts into a coherent, clear and visual system based on five output types of resources formulated in the methodology design (people, finances, technology, standards and law);

[28] Source http://www.eubim.eu/wp-content/uploads/2017/07/EUBIM_Handbook_Web_Optimized-1.pdf
[29] The visual element of the British BIM strategy, presented and discussed in the document entitled "History of BIM implementation in selected member states of the European Union - material supplementary to meetings with the stakeholder", forming another part of this project

- Laying out the above elements on a time axis along with an estimated period of their implementation in relation to the activities of public administration bodies and other entities from the construction market in Poland;
- Inclusion of the most important points in the statement of success conditions for the entire BIM implementation project, both for pilot investments and for further projects.

3.3 Structuring the project environment

In order to be successful at the next stage of evolution in any processes, the current stage must first be sorted out. Taking the Bew-Richards wedge as an example, for the evolution of the BIM methodology, it will be BIM level 1, i.e. traditional CAD with 3D elements for visualization. This is the most common level in Poland for a large proportion of construction investment, with a few higher-level exceptions. Regardless of the level, the structuring of project information to better manage it is a good practice.

Each construction investment starts (apart from the business programming stage) with design data created during its first stages. It is therefore important to create order from the very beginning and maintain it throughout the duration of the investment, so that information management has the right foundation.

In this regard, we may fully base ourselves on the British recommendations. For this purpose, the proposed document is PAS 1192:2007, which visually defines the structuring of production, storage and exchange of information for the delivery stage, i.e. the design and construction stage. After a period of operation proven in the British market, these standards are slowly entering the stage of global standardization in the form of ISO standards. The ISO 19650-1 standard introduces, based on the British proposal, the organizational chart of the digital process environment in the design process (CDE - see point 5.5.2.6) in the subsequent stages: WIP (current own work) > SHARED (joint work in cooperation) > PUBLISHED (work published) > ARCHIVE (work archived).

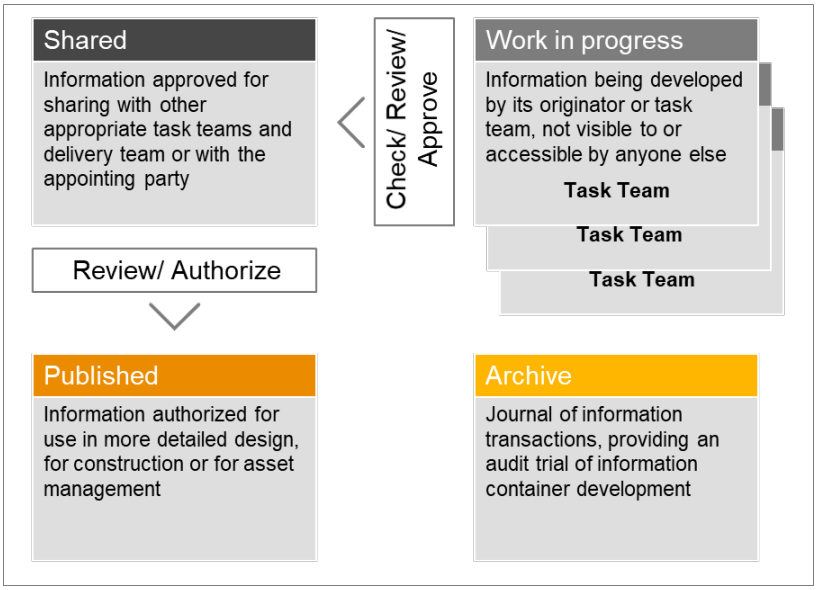

Figure 9: CDE structure, source according to the PN-EN ISO 19650-1:2019 standard [30]

The issue of using the file naming system for the needs of specific projects or its possible extension to the entire public investment system in the country remains open. Practices of the following months will probably show the direction of development that Polish design offices must initiate on their own or in cooperation as part of specific investments. A national system would require a broad consensus of all parties involved in investment

[30] https://sklep.pkn.pl/pn-en-iso-19650-1-2019-02e.html [Access: May 2020] [70]

processes. British BS 1192:2007+A:2106 standard, which is the basis for the PN-EN ISO 19650 standards, recommends only structural schemes of file and folder names, and not specific solutions for naming systems.

Adaptation of a uniform and clear (containing full information in the name) naming rules for files, models and project folders is proposed to allow better communication between participants from the very beginning, i.e. from the design part of integrated processes. Structural design information principles should be applied separately for individual projects.

3.4 BIM process management methods

The integrated process is characterized by a different organization than traditional processes in construction, although the process itself is similar. The added value of the integrated process organization is based on additional resources of knowledge about the process and tools for better production management and information flow.

The Polish (but not yet Polish-language) PN-EN ISO 19650 part 1 and 2 standard[31] published in February 2019 (parts 3 and 5 are under development) details sets of information to be developed by the appointing party for individual stages of the investment carried out in the BIM methodology, imposing on lead appointed parties and appointed parties a requirement to provide feedback on the created asset. This is part of the successful approach in the United Kingdom (the so-called “pull”), which defines the requirements that should be met for the integrated process to be successful.

Further chapters of this strategic study contain elements corresponding to “push” activities, i.e. initiated on the part of entities working in design offices and on construction sites in public investments. Task implementation tools have been defined to ensure that “pull” requirements are met. Only then will the preliminary stage of Convergence mentioned above in the German strategy (focusing, gathering and conformation) lead to the integration of “pull” and “push”, both to unify activities and to facilitate cooperation.

The most important practical goal is to create motivated and committed work teams for all investment tasks, so that one can gradually apply the elements of the investment management process indicated in the standards and norms in the BIM methodology.

The published PN-EN ISO 19650-1 and PN-EN ISO 19650-2 standards are official Polish standards to be used as part of the project delivery. The content of this standard and its next announced parts (PN-EN ISO 19650-3 regarding the operational stage of assets and PN-EN ISO 19650-5 regarding data security) should be adopted and implemented in Polish construction from the moment the standard is published. The Polish Committee for Standardization (PKN) program also contains many other BIM items that will facilitate the implementation of BIM in the Polish market

3.5 Evolution of the work ethos

The work ethos has changed significantly in recent decades. Reduction of working time and remote work have been proposed - and in many cases implemented - and further trends are being investigated to help increase efficiency by creating an optimal work environment. It is becoming obvious that the human factor is the most important asset in national economies. It should be subject to special protection and uninterrupted personal development should be guaranteed to all individuals. The following figure presents a hierarchy of the human values:

[31] These are commercial publications of PKN

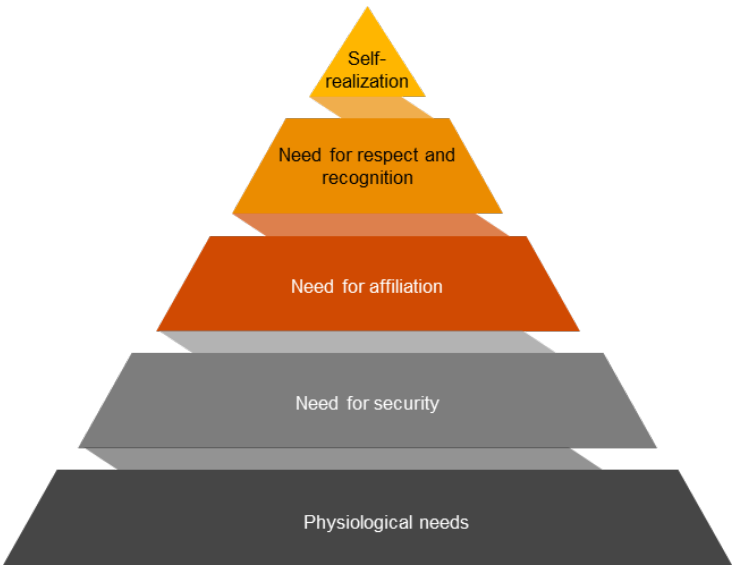

Figure 10: A pyramid of human needs according to Abraham Maslov.

Own elaboration based on [32]

Meeting all these needs is the basis for optimal human functioning in the society. The basic aspects conducive to both the professional development of the individual and his integration in organizational structures is the right learning climate, resulting in understanding and trust, which are the basis for commitment. This creates a development spiral, which is catalysed by the exchange of information in the process.

THE MEANING OF A PROPER AND COMPLETE FLOW OF INFORMATION FOR COMPLEX PROCESSES IN CONSTRUCTION SHOULD NOT BE UNDERESTIMATED.

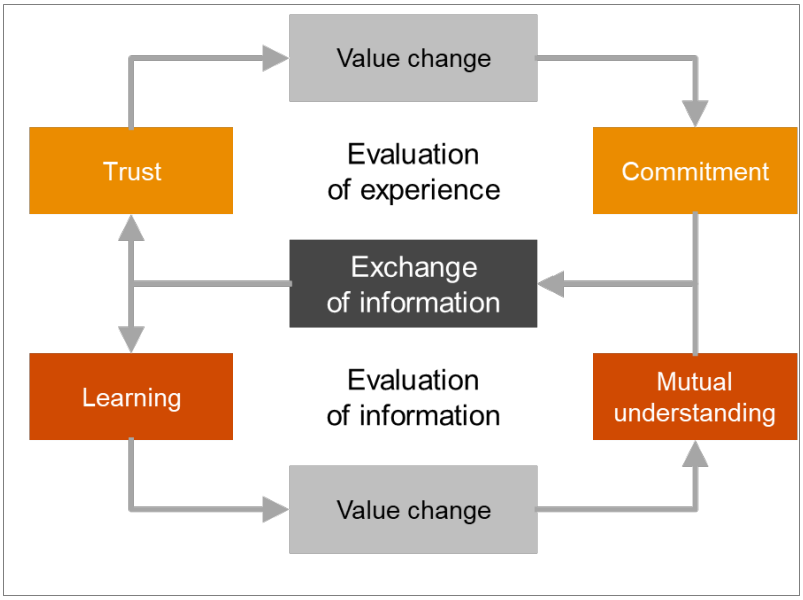

Figure 11: Co-relation of the cycles of raising of trust and the process of learning.

Own study based on [23]

The need for cooperation between all participants in construction processes is also highlighted in the introduction to the PN-EN ISO 19650-1:2019 standard as a key factor in the effective development of

[32] https://pl.wikipedia.org/wiki/Hierarchia_potrzeb [Access: May 2020]

investment assets and their subsequent operation. The introduction to the above-mentioned standard also contains such required values as mutual understanding, trust and proper flow of information in order to reduce risk, losses, controversy or misinterpretation. It is emphasized that currently a lot of expenditure is devoted to repairing unstructured information, erroneous processes of managing this data, solving tasks resulting from the lack of coordination of executive teams due to inadequate information flow and its improper storage and use.

One of the adequate initiatives towards better integration of human power in economic entities is the decentralized method of managing the organization, the so-called turquoise management[33], a concept proposed in 2014 by Frederic Laloux, and practically used and promoted in Poland by, among others, an entrepreneur, Prof. Andrzej Blikle, who called it a "partnership democracy".

ALL FACTORS OF THIS STRATEGIC DOCUMENT, REGARDLESS WHETHER THEY ARE CONDITIONS, A RECOMMENDATION OR ELEMENTS OR NODES OF THE MATRIX, SHOULD BE BASED ON THE EDUCATION AND SELF-EDUCATION OF ALL PARTICIPANTS IN THE PROCESSES CONDUCTED IN THE BIM METHODOLOGY.

> *Considering that human factor management is usually a challenge, it is recommended for each public project to start with a few days of workshops introducing the BIM methodology and cyclical knowledge consolidation training. This is the most desirable method for maintaining the necessary integration of the entire project and executive team, but in the long run it must be underpinned by constant education of all participants in the processes integrated in BIM.*

3.6 Legal considerations regarding BIM – current status

The regulation binding as of the date of this report, regulating the principles of preparing and conducting public procurement proceedings, i.e. the Act of 29 January 2004, the Public Procurement Law (uniform text, Journal of Laws of 2019, item 1843, as amended). - will, from 1 January 2021, be replaced by the provisions of the Act of 11 September 2019 - the Public Procurement Law (Journal of Laws of 2019, item 2019, as amended). – hereinafter referred to as: "PPL". For this reason, this study includes references to the provisions of the Act of 11 September 2019.

The provisions of Public Procurement Law (PPL) were based on the regulations of Community public procurement law deriving from Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement, repealing Directive 2004/18/EC (hereinafter: "Directive 2014/24/EU") and Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on the award of contracts by entities operating in the sectors of water management, energy, transport and postal services, repealing Directive 2004/17/EC (hereinafter: "Directive 2014/25/EU"). The provisions of the directives do not contain specific regulations regarding design requirements using BIM. Nevertheless, in both directives - in Art. 22 section 4 of Directive 2014/24/EU and Art. 40 section 4 of Directive 2014/25/EU, it is indicated that: *for public works contracts and design contests, MemberStates may require the use of specific electronic tools, such as ofbuilding information electronic modelling tools or similar*. At the same time, if such a requirement is formulated, appointing parties must offer alternative means of access to such tools until they become publicly available. Importantly, apart from the quoted provisions, the EU directives do not specify separate, detailed requirements or in any way explicitly refer to the use of electronic building data modelling tools by contractors (lead appointed parties).

In PPL, the above provisions of the directive were implemented in Art. 69 sections 1 and 2 of PPL. Pursuant to this provision, in the case of works contracts or contests, the appointing party may require the preparation and submission of bids or works using electronic building data modelling tools or other similar tools that are not generally available, in which case the appointing party must ensure that an alternative means of accessing such tools is used.

[33] According to Laloux, one of the five methods of organization management, from authoritarian (red) to democratic (turquoise). The other, interim stages are represented by the following colours: amber, orange and green.
https://pl.wikipedia.org/wiki/Turkusowe_zarządzanie [Access: May 2020]

The analysis of the above Community and national provisions leads to the following conclusions:

- On the basis of Directives 2014/24/EU and 2014/25/EU, as well as national legal acts, the provisions regarding the possibility of using BIM refer and have been introduced in accordance with the systematics of the above-mentioned legal acts, to the principles of communication between the appointing party and lead appointed parties. Both Art. 22 of Directive 2014/24/EU (and, similarly, Art. 40 of Directive 2014/25/EU) and the provision of Art. 69 of Public Procurement Law explicitly point to the principles of communication between the appointing party and lead appointed parties, and not to the detailed rules for conducting proceedings regarding contracts for design services or works or the requirements related thereto. Even more emphasis on the link the above-mentioned provisions with the principles of communication is placed by the provisions of Art. 69 section 1 of PPL, which indicates the possibility of formulating a requirement for lead appointed parties *to prepare and submit bids or works using electronic building data modelling tools*, while EU directives use a broader concept: requirements, in works contracts and contests, for the use by lead appointed parties of electronic building data modelling tools.
- Apart from the above-mentioned provisions, neither the EU Directives nor PPL explicitly state the authority, requirement or obligation for appointing parties to apply BIM in public procurement procedures. However, the lack of such an explicit authorization or obligation does not mean that appointing parties are deprived of the right to formulate requirements for the implementation of project documentation using BIM, whether as part of service contracts (preparation of project documentation) or as part of works contracts (in the “design and build” or “build” formula). The use of BIM to prepare project documentation (for the Building permit or for execution) and the use of the BIM model in the implementation of construction works or the provision of maintenance services (facility management) is only a tool to achieve the goal and determine how to perform the subject of the contract, including how to prepare the project documentation or perform construction works using the electronic modelling method. Moreover, according to the provisions of Art. 22 of the Directive and Art. 69 of PPL, which relate to the form of the offer and communication between the appointing party and the lead appointed party, the admissibility of formulating BIM requirements and preparation of the offer using BIM in public procurement procedures should be considered as permitted. Since the EU legislator and national legislator allow the submission of an offer using BIM, they also allow the formulation of requirements for the use of BIM, both at the stage of preparing the offer and at the implementation stage of the public contract. Notwithstanding the foregoing, the use of BIM should always result from a description of the requirements formulated by the appointing party in the procedure documentation (terms of reference, description of the subject of the contract) as part of a given public procurement procedure.
- Both under the Community public procurement law and national law, the provisions relating to the use of specific electronic tools, such as electronic building data modelling (BIM) tools, are a right rather than an obligation. In other words, Member States may or may not require the use of electronic building data modelling tools. According to the above, under the Polish law, the imposing of a requirement on the lead appointed party to use BIM tools to prepare an offer is a right, not an obligation of the appointing party. Given the nature of the provisions of the Directive, which set minimum standards, the above does not, however, exclude the possibility for the Polish legislator to introduce a mandatory requirement as to the use of electronic building data modelling in the preparation of offers.

Therefore, the national regulation of public procurement does not prevent the use of BIM in public procurement, the best example of which are proceedings based on Public Procurement Law, which include the use of BIM. Nevertheless, in order to popularize and broaden the use of this model, legislative actions in the area of PPL and at the level of BIM promotion, as part of shaping the state’s procurement policy within the meaning of Art. 21 of PPL, may be necessary. According to the above article, as part of the procurement policy of the state, the priority activities of the Republic of Poland in the area of public procurement, as well as the desirable direction of appointing parties with regard to awarded contracts are specified. Such directions relate, in particular, to the purchase of innovative or sustainable products and services, taking into account standardization aspects, cost calculation in product life cycle; dissemination of good practices and procurement tools, or applying social aspects. Preparation of the draft of the procurement policy and coordination of the implementation of such policy is the responsibility of the minister competent for economy. In addition to legislative measures, consideration should therefore be given to stimulating measures to promote BIM by shaping procurement policy and promoting innovation.

Regardless of the actions that may be taken on the basis of the provisions of PPL in the area of broadly-understood public procurement, the legislative system in Poland, in particular in the area of administration digitization, the process of obtaining building permits as well as conducting and supervising the investment process, is not yet prepared for the implementation of BIM. In order to fully prepare the digitization of integrated construction processes, it is necessary to provide tools, including legal solutions that will allow for the fullest possible use of the potential arising from the digitization of the construction process. In the long term, such legal solutions should be developed through amendments to regulations, at the statutory or executive level, relating to the process of creating project documentation and obtaining a building permit.

On the other hand, it is necessary to develop standards (e.g. construction classification, contract templates, model documents related to conducting an investment process in BIM), taking into account the interests of all market participants, that will not hinder competition.

The most important Polish legislative activities should, first and foremost, focus on the following three elements:

- PPL (division of bid evaluation criteria in line with the growing importance of the BIM integrated methodology in public procurement; consideration of the obligation of certain categories of appointing parties to use BIM in the case of investments with an estimated value exceeding the set quota threshold; development of model documents and contract templates or model contract provisions);
- Implementing regulations (development of building classification in accordance with BIM digital processes);
- Preparation for ordering an IT platform[34] aimed at motivation, technical support and education of public appointing parties in Poland.

Further:

- Amendments to the Regulation on methods of calculating the life cycle costs of buildings and the method of presenting information regarding these costs[35];
- Amendment to the Cybersecurity Act[36], taking into account new distributed technologies.

THE PURPOSE OF THESE CHANGES IS PREPARATION TO THE IMPLEMENTATION OF BIM IN POLISH PUBLIC INVESTMENTS IN TWO STAGES: FIRSTLY, OBLIGING A CERTAIN CATEGORY OF PUBLIC PROCURERS TO APPLY BIM IN THE PROJECTS ABOVE CERTAIN ESTIMATE CONTRACT VALUE AND APPLY CRITERIA OF BID EVALUATION, TAKING INTO ACCOUNT THE MINIMUM WEIGHT OF BIM METHODOLOGY, AND, IN THE SECOND STAGE, SET THE DEADLINE FOR THE OBLIGATORY APPLICATION OF THE BIM METHODOLOGY IN ALL PUBLIC INVESTMENTS ABOVE A CERTAIN ESTIMATE CONTRACT VALUE.

In this way, it will be possible to prepare the construction industry for the introduction of the BIM mandate (which has been already introduced in many countries)[37].

[34] The IT platform referred to in the document will be discussed in a separate study regarding this project
[35] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20180001357/O/D20181357.pdf [Access: May 2020] [71]– the legislative proposals are described in point 5.7.1
[36] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20180001560/T/D20181560L.pdf [Access: May 2020] – the legislative proposals are described in point 5.6.1
[37] https://iopscience.iop.org/article/10.1088/1755-1315/410/1/012073 [Access: May2020] [55]

It is suggested to divide legislative activities into priority and secondary, in two stages. It is recommended to amend the provisions of the Public Procurement Law, as well as to adapt the executive provisions[38] which are currently based solely on the codes of the Common Procurement Vocabulary (CPV) - additional reference to the classification in construction projects for the Polish market is recommended. The last priority is the implementation of an IT platform to support public investments implemented in the BIM methodology, according to the specifications of this project.

3.7 The most important starting aspects – summary of the boundary conditions

- STRUCTURING THE PROJECT ENVIRONMENT;
- BIM INTEGRATED PROCESS MANAGEMENT;
- WORK (HUMAN ASPECT AND LEAN FOR CONSTRUCTION);
- LEGISLATION (PUBLIC PROCUREMENT LAW, AUTHORIZED CONSTRUCTION CLASSIFICATION).

[38] Regulation issued on the basis of Art. 34 section 2 of PPL regarding the methods and grounds for preparation of the investor's cost estimate, calculation of planned costs of design work and planned costs of construction works, specified in the functional-utility programme and regulation issued on the basis of Art. 103 section 4 of PPL, specifying a detailed scope and form of design documentation, technical specifications of execution and commissioning of construction works, the functional-utility programme. The aforementioned regulations correspond to the regulations issued on the basis of Art. 31 section 4 of the Act of 29 January 2004 r. - the Public Procurement Law, i.e. Regulation of the Minister of Infrastructure regarding a detailed scope and form of design documentation, technical specifications of construction works execution and commissioning and the functional-utility programme (uniform text, Journal of Laws of 2013, item 1129) and Art. 33 section 3 of the aforementioned law, i.e. the Regulation of the Minister of Infrastructure regarding the specification of methods and basis for preparation of cost investor's estimates, calculation of planned costs of design works and planned costs of construction works, specified in the functional-utility programme of 18 May 2004 (Journal of Laws No. 130, item 1389).

IV. Road to BIM in Poland

PwC

4 Road to BIM in Poland

4.1 General strategy

In order for modernization activities for Polish construction to be fully called “the strategy for Poland”, as part of the developed Roadmap, it would be necessary to extend them to the digitization and technological progress of the entire Polish economy, just like the British Digital Built Britain, i.e. Digital Built Poland). Only then will it be possible to integrate factors unrelated to construction but appearing and functioning in a geospatial environment. The driving force behind the creation of such a strategy for Poland should be the highest levels of state administration, as this is a “pull” action.

Even though there is a document of the operational program “Digital Poland for 2014-2020”[39], developed by the Ministry of Investment and Development with the support of EU funds, but it ends in 2020 and there is no continuation. EU funds for similar strategic goals for 2021-2027[40] have already been allocated, so we should consider preparing the next part of the digital strategy for Poland, following the example of the Czech Republic, as discussed above. In January 2020, the Integrated State Computerization Programme [41]was updated again, which is a continuation of the strategic direction of central institutions that can be helpful in the process of BIM implementation.

This chapter, as well as the entire project, focus on the BIM strategy, because it is the most practical application of digitization in construction, but it should be borne in mind that this is only a part of the digital environment for Poland. BIM itself relies more on created assets than on a human factor, more on the supply of assets than on their operation, and therefore covering the entire investment cycle requires its supplementation with other elements, not necessarily associated directly with the Building Information Modelling methodology, such as Lean or ecology. These elements are also incorporated in this study.

Taking into account the challenges associated with the implementation of BIM in many countries of the world (also indicated in earlier parts of the document), both of a technological and general social nature, it is proposed to extract the essence of integrated processes in the form of several elements for easier understanding of the entire BIM methodology. The base should be as clear as possible, and in the future - in subsequent studies - more detailed guidelines should be provided on its basis. The best solutions are the simplest solutions.

While dealing with such a complex issue, it is impossible to avoid certain logical, technological and procedural complexities. But this will be significantly reduced. In accordance with the idea of visualization, on which both BIM and Lean are based, the best optical clarity of individual elements and the entire system of the integrated process will be used for better assimilation.

It should be noted that - especially due to the inclusion of barely emerging technological trends in the Roadmap - this study may become obsolete in the technological aspect even in the near future. Therefore, it is recommended to regularly update this document every 2-3 years.

The essence of the BIM processes is their integrated character. It is impossible to enumerate all types of integration occurring in construction investments in this methodology, but a good illustration is the indication of the main focuses of integration based on the example of figures taken from the collective work entitled “Integrating Project Delivery” [24]. The central place (High Value Facility) is occupied by the planned and constructed High Value Facility, defined by the appointing party, surrounded by forms of comprehensive integration in the MacroBIM[42]stages, both delivery and operational. The characteristics of the aforementioned stages is described in the further part of the study.

[39] https://www.polskacyfrowa.gov.pl/media/55216/POPC_Program_3_0_17042018.pdf [Access: May 2020] [72]
[40] https://www.funduszeeuropejskie.gov.pl/strony/o-funduszach/fundusze-europejskie-2021-2027/ [Access: May 2020]
[41] https://www.gov.pl/web/cyfryzacja/program-zintegrowanej-informatyzacji-panstwa [Access: May 2020] [73]
[42] The pre-delivery phase, explained in chapter 5.2

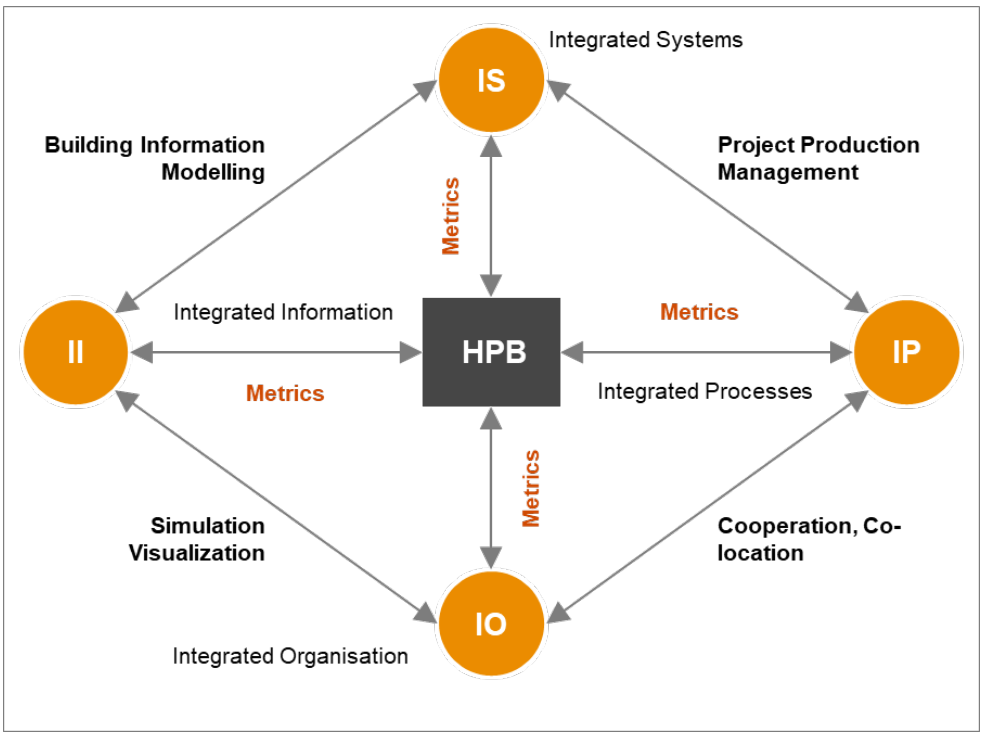

Figure 12: Simplified framework of integrated processes[43]

BIM processes should be treated as sets of cooperating elements that will only bring measurable effects (economic, social and ecological) when all their components are used. BIM starts from the first minute of the investment process.

4.2 Elements of the matrix

The first task is to specify and analyse all relevant aspects that are part of integrated processes in the Polish market, in order to implement the BIM methodology in it. The methodology of this Roadmap development assumes five groups of assets as a starting point:

- people;
- finance;
- technology;
- procedural standards;
- law.

In the analytical process, additional 8 were separated and allocated to these 5 elements, which were partially integrated and then all structured into 3 stages:

- investment stages (work plan, MacroBIM, delivery phase and operational phase);
- production elements (technology, cybersecurity, Lean/processes, classifications and ecology);
- control factors (law/normalization, standards and finance).

[43] Own elaboration based on: "Integrating Project Delivery" [24]

In the process of synthesis and for better visualization, the elements of investment and production stages are presented as a matrix of 9 elements, of which four represent the stages of investment preparation and execution (subject to the time aspect), and the remaining five support them in terms of substance. The remaining 3 control factors, as occurring in each of the other 9 elements, were divided equally between them.

Matrix elements contain both recognized methods and procedural standards for processes integrated in construction, but also new factors not usually found in strategic studies conducted for BIM. All of them are discussed in the descriptive chapter of matrix elements.

Presentation of the elements of the Roadmap in a structured way will provide for the specification and assessment of work inputs (marked as matrix nodes - chapters 1 i 1), necessary to achieve readiness for the mandatory implementation of BIM in a few years.

Below is a list of elements necessary to complete the “BIM for Poland” matrix. They will form the basis for the structure for the use of BIM in the Polish construction in the future.

Investment stages (each accompanied by the required training):

- **1 – Work plan** (orientation strategies like this document for the Roadmap or the “Poland 2030. The third wave of modernity” strategy[44]; Polish BIM standards; new definition of investment stages; ICT development; roles in BIM processes; investments in research and development activities; industry cooperation with the academic community; full-time studies; work on win-win contracts; definition of pilot projects; media work for promoting BIM in Poland);
- **2 – MacroBIM** (construction investment programming; SWZ (Specification of Order Terms) + BIM; BIM Protocol; Target Cost and new types of cooperation contracts; Systems & Design Thinking);
- **3 – Delivery phase** (design and execution - asset delivery: pre-contract BEP + BEP; AIR + OIR + PIR + EIR; MIDP + TIDP[45]; Risk Register and Risk Management; automation - prefabrication; PIM - Project Information Model);
- **4 – Operational phase** (Facility Management during the business operations and facility operation stage for the entire lifetime of the investment asset - “asset management”: COBie; AIM – Asset Information Model; Digital Twins; Life Cycle Assessment; recommended study: Digital Built Poland (based on Digital Built Britain)[46]

The substantive basis (including the required training):

- **A – Technology** (“pull” and “push” initiatives; structuring and standardizing information - standards; CDE; software and hardware; Big Data; Edge Computing; open formats and technological support);
- **B – Cyber security** (GDPR; copyright; DLT - Distributed Ledger Technology - distributed processing; Cyber security reports);
- **C – Lean methods** (methods of loss-free construction investment: human factor - Integrated Team; Lean tools from industry – TPS – Toyota Production System; Agile - agile methods - Scrum; TVD - Target Value Design; LPS - Last Planner® System[47] – schedules; CbA – Choosing by Advantages);
- **D – Classification, LOG/LOI** (standards for classification; building classification for Poland; LOD = LOG + LOI; Decoupling - separation of geometric and alphanumeric information; object libraries);
- **E – Ecology** (Sustainability; Circular Economy; Low Emission and Energy Efficiency; PED - Positive Energy Districts; “Push” Initiatives).

[44] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WMP20130000121/O/M20130121.pdf [Access: May 2020] [75]
[45] Abbreviations explained in chapter 5.3
[46] The document explained in chapter 5.4
[47] Last Planner® System is a system of schedules for the process of asset delivery, i.e. the executive process. The system can be freely used, but the use of its name in documents requires the registration mark® after the word “Planner” (source: https://leanconstructionblog.com/What-is-the-Last-Planner-System.html – [Access: May 2020] More about the system in chapter 5.7.2.13

The matrix assumes an additional stage in the investment process, called MacroBIM[48] (BIM at the investment programming stage), which is to provide investment security in economic terms. This stage does not yet exist in investment processes in Poland, but ultimately it is suggested to introduce it for the benefit of every construction investment, whether public or private.

Because it is a new element, it requires a special description, also in this schematic specification. This is the financial part of the investment programming stage. In this Roadmap MacroBIM phase is assumed as the part of public procurement proceedings.

In its assumption, MacroBIM is the stage in which the potential lead appointed parties present a massing model concept or functional system based on the appointing party's requirements formulated in the Terms and Conditions of Purchase (SWZ) with elements of the BIM methodology. Along with the concept, contractors submit an index calculation of the facility (there are specially prepared catalogs for that purpose in the market). The indicator calculation is then verified against market prices. Price indicators, in addition to the schematic massing-functional concept, constitute an important part of the submitted offers. They are used to assess whether the investment is feasible within the budget assessed by the appointing party. In the event of positive evaluation and acceptance of the proposed concept by the appointing party, these indicators are used to negotiate the Target Cost of the planned project between the potential lead appointed parties submitting the initial offers [49] and the appointing party. It should be noted that the most advantageous offer still does not guarantee the implementation of the investment, but it should be obtained like any market product with the participation of stakeholders from potential lead appointed parties in the investment process after initial prequalification and with the commitment at the earliest possible stage, in addition to designers, as well as specialized engineers, contractors of construction works and future asset users.

An important difference of such proceedings[50], in relation to the currently most-commonly used procedure of awarding a public contract, i.e. an open tender, is its two-stage character, guaranteeing a thorough check of the investment's profitability and the possibility of specifying the offer and negotiating the Target Cost. Another benefit of this stage is constituted by financial savings for all parties in the event of the project being unprofitable, as well as the possibility of correcting the expectations of the appointing party in order to match the investment objective with the funds allocated to its implementation. The prequalification system will also allow for limiting the number of bidders to select the lead appointed party for an investment task in terms of substance, economy and organization.

An example of an investment that was rejected by the City Council after analysing the concept by architect Frank Gehry is the design of the Festival and Congress Centre for the New Centre of Łódź[51]. And although this concept was beyond the scope of MacroBIM's intended purpose in this document, the principle behind its evaluation is based on similar assumptions to avoid the risk of overpaying for a future facility after its completion.

Certainly, an introduction of a separate MacroBIM stage would create a new type of business relationship in construction, as it would require close cooperation at the bid stage of both designers and construction contractors, and future users.

The second element of the matrix, unheard of in foreign strategies, is the Lean ecosystem, which has entered the industry for good (Lean Industry) and has been making its way to the construction industry (Lean Construction) for several years.

Ecology and classifications are a logical complement to taking into account environmental goals and supporting automation in construction processes, especially prefabrication, as well as supply and logistics.

[48] There are 3 degrees of detail of analysis of a given phenomenon or process: Macro (aimed at the examining of the general structure and relations in a given system), Micro (a detailed analysis of all key attributes and system relations), Meso is an interim type. The MacroBIM discussed here is an approach to BIM from the perspective of a large scale, without going into details.
[49] The applied MacroBIM stages are incorporated in the procedure of negotiation with an announcement. The term of "initial offers" was used intentionally
[50] The MacroBIM stage is a part of the procedure for the award of the contract, and not the stage preceding the initiation of the proceedings
[51] https://tech.wp.pl/szef-camerimage-jedzie-do-ministra-kultury-6032727646999169a [Access: May 2020]

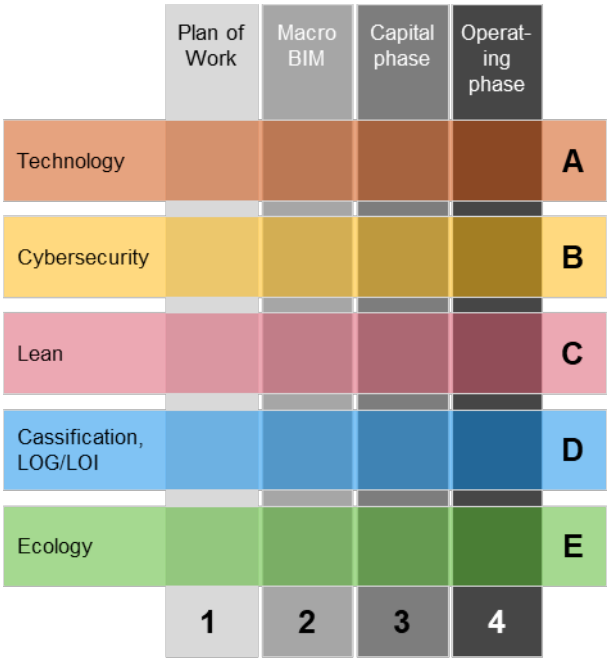

Figure 13: Matrix of elements of the BIM strategy implementation in Poland under the Roadmap.

Own elaboration

The list of elements is not exhaustive, it is possible to supplement the matrix with more parts in the future and possibly reallocate them under new conditions. Apart from the simplicity of the system, its flexibility is equally important. Nodes of matrix A1 - E4 (points 6 and 7 of this document) have been given names only for better orientation and not as a set standard.

A legislative, normative, customary or cultural basis has been created for all elements of the matrix. The goal is to structure all data and, as a result, to facilitate the absorption of the Roadmap by the entire construction market, which consists of about half a million participants in Poland (- 420,000 - data for the first quarter of 2019)[52], including many of those for whom Polish is not a mother tongue.

Since the proposed approach to the issue of digitization of construction in this form has not been presented anywhere so far, some elements will require further actions fixing them in Polish construction (legally or customarily) in order to be considered stable in the whole system. These elements are generally not alien to integrated investments, but so far, they have not been presented in this way and in such a combination.

Figure 14: Specification of the stages of the asset delivery and its management, conducted in the BIM methodology.

Own study

[52]https://www.muratorplus.pl/biznes/raporty-i-prognozy/branza-budowlana-maleje-zatrudnienie-mimo-wzrostu-plac-aa-mHPj-mT7R-o9og.html [Access: May 2020] [76]

Although the individual investment stages are also subject to integration and partial overlapping (as can be seen in the above figure illustrating the investment's progress over time and approximate size proportions of its stages), nevertheless for the purposes of visualizing the Roadmap strategy, they will be distinguished and presented separately, taking into account at the same time, their different nature and substantive basis.

"Asset" is defined in the ISO standard as the target product of the construction or infrastructural investment, including the subsequent process of management of its whole life cycle. This is an illustration of the idea of investment proceeding based on: "Begin with the end in mind" [25] constituting a challenge for designers, for whom the product usually is not an asset yet, but still their own design. Here, we can distinguish between the stage of asset development and the stage of its management.

This will also facilitate the definition of nodes at the intersections of matrix elements, for their individual analysis. This is aimed to focus activities standardizing specific sections of the investment process. This will strengthen the structure of the entire system and will be a step towards creating a visual workshop - the Lean ecosystem domain.

TO SUM UP THE GENERAL DESCRIPTION OF THE WHOLE MATRIX, IT SHOULD BE EMPHASIZED THAT IT IS UNDERSTOOD NOT AS A LIST OF ANY ELEMENTS FROM WHICH YOU CAN CHOOSE YOUR OWN SET, BUT AS A TARGET SYSTEM. RELYING ON STANDARDS, TECHNOLOGY OR ENVIRONMENTAL REQUIREMENTS WILL NOT BE SUFFICIENT WHEN THE HUMAN PERSPECTIVE IS NOT TAKEN INTO ACCOUNT IN INTEGRATED PROCESSES OR NO CLASSIFICATIONS OR OPTIONAL CYBERSECURITY CONDITIONS ARE DEVELOPED. THE SYSTEM WILL FUNCTION FULLY ONLY AS A WHOLE.

THE PRESENTED MATRIX DOES NOT REFLECT MAJOR CHANGES IN THE CONSTRUCTION PROCESSES IN COMPARISON WITH TRADITIONAL METHODS. ITS SPECIFIED ELEMENTS ARE ONLY AIMED AT THE FACILITATION OF THE ACTIVITIES UNDERTAKEN SO FAR, IN VIEW OF THEIR EFFECTIVENESS, ECONOMY, CO-OPERATIVENESS AND INFORMATION FLOW.

V. Detailed elements of the matrix

5 Detailed elements of the matrix

5.1 Plan of work for Poland (this document and strategic derivative documents)

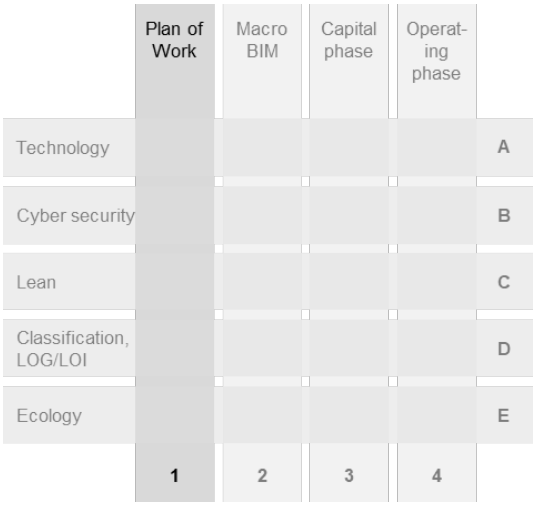

Figure 15: Plan of work – the first element of the matrix for phases of the investment.

Own elaboration

5.1.1 Legal-normative ecosystem

The Plan of Work does not possess normalization nor legislation subbase. It will contain, first of all, the Roadmap but also all documents and programs (e.g. Standardization of services of Hub of Digital Innovations to support the digital transformation of enterprises" within the frames of the Minister Program for the years 2019 – 2021 entitled „Industry 4.0")[53] [54] established or still being established in Poland which direct the BIM development with reference to strategy, namely allowing to obtain the whole view on the BIM methodology. Many of these documents maybe will not obtain the status indicating for the BIM road in Poland, but some of them will certainly find themselves in commonly recognized set of key studies towards creating the cooperation methodology and integration in Polish building sector.

AS POLAND IS JUST AT THE BEGINNING OF THE NORMALIZATION AND STANDARDIZATION ROAD FOR THE BIM METHODOLOGY, ONE SHOULD RECOGNISE THIS ELEMENT OF THE MATRIX AS AN OPEN SET, TO BE FILLED IN WITH CONTENT IN THE FUTURE.

5.1.2 Description

One may assume that Polish Plan of Work[55] uses the structure of the British Digital Plan of Work (DPoW)[56], as it contains also specification of the investment phases. The Polish Plan assumes in addition developing basic

[53] https://pl.wikipedia.org/wiki/Czwarta_rewolucja_przemysłowa [Access: May 2020]
[54] https://www.piit.org.pl/o-nas/aktualnosci/informacja-o-konkursie-standaryzacja-uslug-hubow-innowacji-cyfrowych-dla-wsparcia-cyfrowej-transformacji-przedsiebiorstw-w-ramach-programu-ministra-na-lata-2019-2021-pn.-przemysl-4.0 [Access: May 2020]
[55] List of all initial activities, necessary to launch the process of BIM implementation in Poland. Full definition in Dictionary.
[56] Ang. Digital Plan of Work – a strategy of investment stages in BIM methodology, developed by the Royal Chamber of Architects in Great Britain (RIBA)

guidelines which should be accepted or are just prepared so that integrated investment process could be started at all and be properly led further on.

5.1.2.1 BIM Normalization for Poland

- Accepting the ISO standards, being translation of world BIM standards created on the basis of the British PAS and BS, respectively and adequately for all nine elements of the matrix is obligatory for the success of the BIM methodology in construction and infrastructural investments. The BIM is a strategy, covering all areas of creating the information for the integrated processes. The graphics below, illustrating the environment of the BIM standardization comes from technical report JRC „Building Information Modelling (BIM) standardization" [26] of 2017, supported by the European Union:

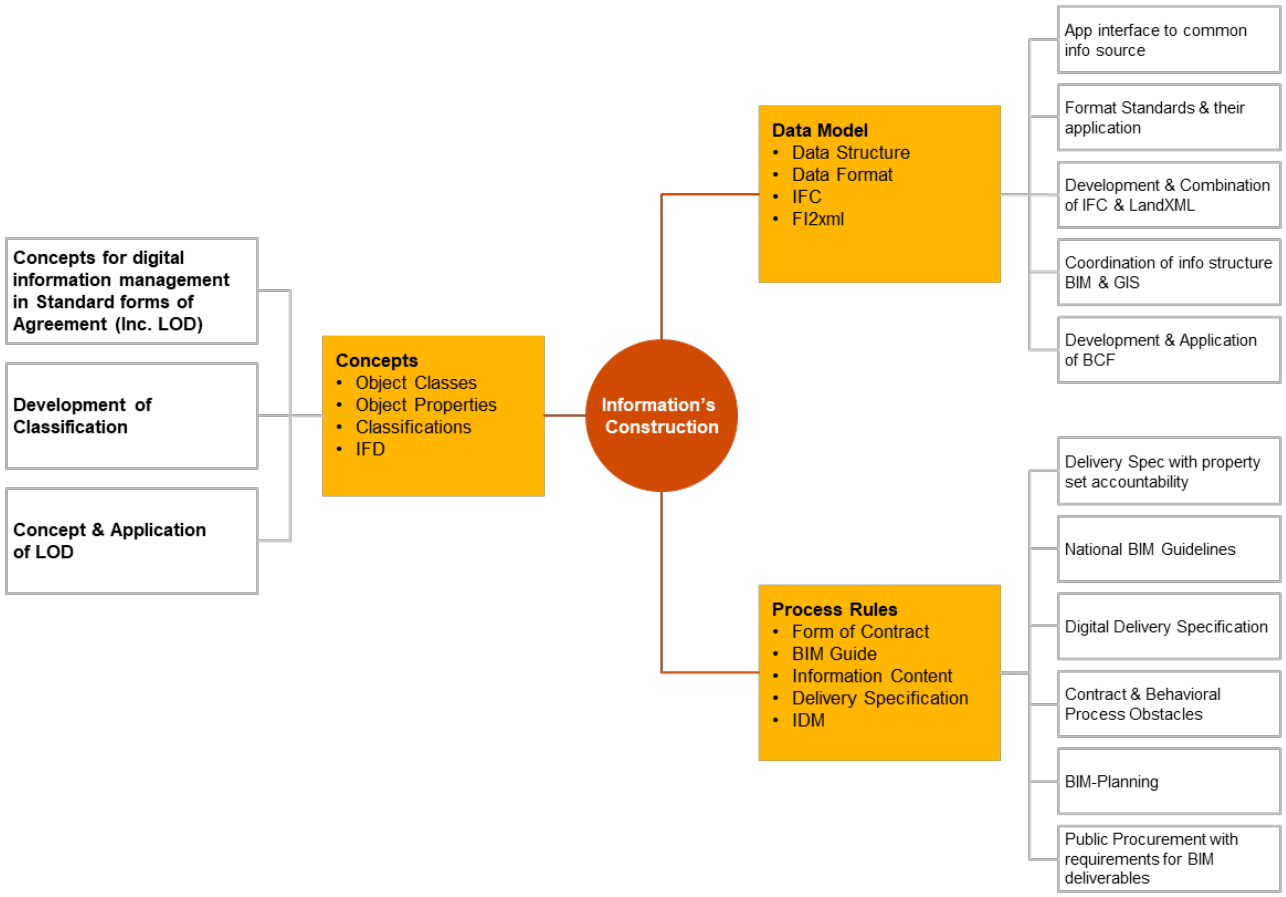

Figure 16: BIM standardization platform [26]

- Accepting and adaptation of actual and future world strategies in areas of ecology, technology, data safety and others, adopted in consultation with current political environments in Poland;
- Accepting the structurising arrangements of the matrix from this document;
- Accepting settling documents created in the future and standards in order to flexibly fulfill the strategic structure.

5.1.2.2 Boundary conditions from chapter 3 of the document

- Structurisation of the actual level 1 BIM (CAD) by the standard PN-EN ISO 19650-1:2019;
- Accepting mental readiness for changes in methods of managing the project environment (by the series of PN-EN ISO19650 standards and other standards which organize the project-execution process);

- Support for the evolution of the work ethos (gaining trust, cooperation, learning and transparency);
- Legislative changes, supporting BIM development (PPL – Public Procurement Law Act including preparation of a procurement policy, Building Law, and regulations concerning conducting building investments);

Creating specification and purchase of IT platform supporting the realization of the investment in BIM methodology by the concept developed in another part of this project[57]

5.1.2.3 Additional phase of conducting the investment

- Program phase of the investment and economic verification of the its subject. It means separation from the delivery phase of an additional pre-delivery phase (programming and verification), called **MacroBIM**. The purpose of the new phase is the economic review of the investment in procedure for awarding public procurement[58]. The result of this analysis is either further proceeding in the same process (which goes to the deliveryphase) or completing the procedure and abandoning the investment idea[59];
- Delivery phase (project-execution), creating unity with the MacroBIM phase. The MacroBIM phase is a part of the procedure for awarding the procurement and not the phase preceding the commencement of the procedure;
- Operational phase with utilisation of the asset (demolition or restauration/extension).

5.1.2.4 Changes in the environment of the building sector and public administration

- Creating the Steering Committee suggested in earlier studies for managing the BIM implementation, in Polish economy. It is to be the body gathering in its activities „top-down" decision making process on BIM in Poland, with the development minister as the leader and with selected advisors;
- Establishing similar units which organise the work in BIM in the bodies of the units of the level of governmental and self-governmental administration connected with the investment-building process;
- Increasing the outlays for the Research and Development sector as without its participation, the technological support for the BIM processes will not be possible;
- Establishing closer cooperation of the industry with the academic sector;
- Establishing and implementing programs of regular studies on BIM at technical schools in Poland, but also in all technical schools of secondary level, connected with construction industry.

5.1.2.5 Definition of roles of participants of the processes integrated in BIM methodology

Table 2. BIM Modeler (modelling information):

Tasks	Notes	Organization membership	Education / skills
Modelling digital information on created asset, both geometrical-topology and alpha-numerical export of data to IFC[60]	Most technologically advanced participant of processes with reference to data service for the information model PIM[61]	Each sector of creating and evaluating the digital model of information on the asset	Technical / service of BIM programs, command of stages of creating the asset on the construction site

[57] Topics of platform will be developed in another study, realized within this project.
[58] Hereinafter referred to as the „procedure"
[59] Completing the procedure on the stage described would be justified e.g. with exceeding the budget thus within the frames of the prerequisites for invalidation of the procedure defined in PPL
[60] IFC – basic format of data exchange in the integrated BIM processes. Full definition in the Dictionary.
[61] Project Information Model - model of the information developed for the created asset in delivery phase. Full information in the Dictionary.

Table 3. BIM coordinator (control and deliveryof modelled information):

Tasks	Notes	Membership organisation	Education / skills
Coordination of the model with reference to the contents of information, correctness of IFC parameters and methods of data exchange with other participants of the processes	Skilled in open formats of exchange of information and tasks of project branches	Each sector of creating and evaluation of digital model of the information on the asset	Higher or secondary technical / operation of all formats of information exchange for a specific investment

Table 4. BIM Manager (distribution of the information shared between the participants):

Tasks	Notes	Organizational membership	Education / skills
Coordination and management a technological site of the BIM processes with all participants, managing the information on assets in all project models (open formats on the basis of the ISO standards – see point 5.5.2.5)	Skilled in requirements for the project model for the workmanship	Preferred role of a specialist for each of the main three parties: appointing party, project team and execution team,	Higher technical or bachelor /troubleshooting, soft skills, coordination of building sectors

Table 5. BIM Leader (lean information management in the BIM methodology):

Tasks	Notes	Organizational membership	Education/ skills
Coordination of all parts of the process in the integrated BIM methodology between all participants, irrespective of the branch, degree of technological advancement or the process stage	Skilled in the whole integrated process in BIM	One specialist for the whole investment, any membership, also external, member of Core Group,[62]	Higher, not necessarily technical or bachelor / troubleshooting, soft skills, manager of digital building processes and Lean tasks

5.1.2.6 Adoption of additional orders supplementing the Plan

- Information and Communication Technologies – constant technological progress – it will be especially significant in the element of the matrix with the name Cybersecurity;
- Game Theory, dealing with the mathematical strategic models of interaction between the decision makers in all types of processes, sees the future in „win-win" relations, namely in benefits for all parties to the relations. It resulted from tests over the results available of fiction games types (Role Playing Games) conducted in 60s and 70s of the 20th century at University of Michigan (Robert Axelrod)[63]. On a long-term basis (in thousands of cases) and outside the limits of error, the best results were achieved by the figures with the profile avoiding the conflicts and promoting the purposes of uniformity and profits for each party by means of cooperation. Such an attitude requires mutual understanding, an ability to listen, empathy and trust which are also the basis for the processes in the BIM methodology and were included in limit conditions for the strategic matrix. It is recommended to accept and implement the systematic implementation of the approach in the scope of achieving the „win-win" balance in business transactions, based on the model of "constant improving" in the scope of Lean, entered already also in the first Polish standards BIM PN-EN ISO series 19650.

[62] Core Group consists of the main participants of the investment process: appointing party, designers of particular sectors and contractor of building works. This is a decisive group, co-responsible in risks and bonuses of the process. Full definitions in a separate Dictionary.
[63] https://en.wikipedia.org/wiki/Robert_Axelrod [Access: May 2020]

5.1.2.7 Pilot projects

The task of the public entities is to define and prepare specific public investments as the pilot projects to realize them in the BIM methodology with the use of proper incentive contracts and standards, entered in another part of the study (”Managing the building investment in BIM methodology – proposal of the templates of the BIM documents”).

5.1.2.8 Media work over BIM propagation and its implementation strategy

The propagation of BIM on the media, during construction sector conferences or by means of the publications devoted to the issue as a part of BIM implementation strategy in Poland.

5.1.2.9 Trainings

The Plan of work does not foresee any additional trainings in the scope of its components, but it is required to create the official documents, describing all entered interdependencies and giving the direction for implementing the BIM in Poland by central and local entities. The implementing activities should be initiated and coordinated both bottom-up and top-down.

5.2 MacroBIM – investment programming

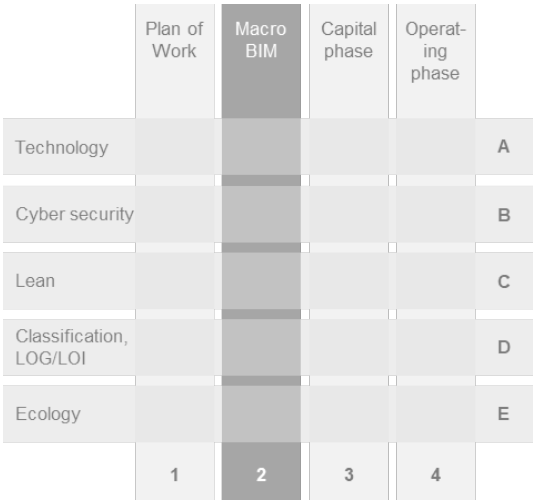

Figure 17: MacroBIM – second element of the matrix for the phases of the investment phases.

Own elaboration

5.2.1 Legal-normative ecosystems

- The idea of the initial phase of the investment is contained, in fact, in the strategic document prepared by the British Chamber of Architects RIBA (Royal Institute of British Architects)[64] called colloquially Digital Plan of Work (DPoW), but its potential seems nowhere used. DPoW describes the activities of BIM for the next stages of the investment in a fluent, uniform process which is characterised by the delivery of partial project information called Data Drops (projections of data), in each stage of the system except for the first stage of developing the strategy of the undertaking. The DPoW concept does not foresee

[64] https://en.wikipedia.org/wiki/Royal_Institute_of_British_Architects [Access: May 2020]

however earlier, separate economic person for the avoidance of financial mistakes[65]. The conditions of launching a separate MacroBIM decides about that or the appointing party at his own risk;

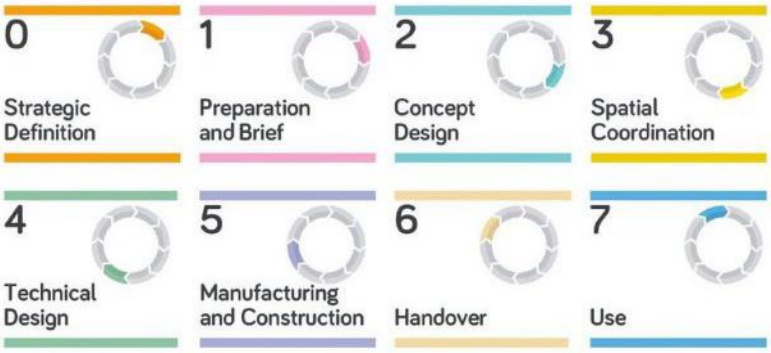

Figure 18: Digital Plan of Work (DPoW) in version of 2019[66]

- The second requirement for MacroBIM is the plan of the undertaking developed by the appointing party in the form of documents required in the ISO 19650-1:2019 standard for defining the conditions of the investment. The only difference between OIR-PIR-AIR-EIR[67] for the stage MacroBIM in comparison with the delivery phase constitutes the lack of necessity to define these requirements by the lead appointed party (coordination with the requirements of the appointing party will be necessary in the delivery phase to develop common requirements for the whole investment);
- **PAS 91:2013+A1:2017** is British document used for securing the ordering party by means of the requirement to provide the answer to the set of questions **PQQ (Pre-Qualification Questionnaire)**[68] by the person appearing for the procedure in the phase MacroBIM of the contract. The qualification requirements may be extended by the appointing party to obtain the required quality of offers and their creators;
- **A –** The first required scope of questions refers to: identification of the bidder, financial information, condition of the enterprise and professional qualifications and policy of the entity concerning safety and health;
- **B –** The second set is optional and refers to the policy of competitiveness, environmental, management quality of the processes and qualification in proceeding the BIM methodology;
- **C –** The third required set refers to qualification of the entities in case of taking part by them in public tenders both for the civil and military sectors.

The document was not raised yet to the rating of British standard (BS), and at the same time it is not the ISO standard for BIM. Despite that one should expect its standardization, as it is still made validated and its nature is favorable for earlier control over the investment process. Taking into account the nature of the MacroBIM phase, it would be the first possibility for the appointing party to assess the usefulness of the offers in the procedure with reference to organisation.

[65] The previous activities undertaken for review of the reasonability of the investment of the public purpose, always are based only on the estimates. Frequently also the works over launching the investment last very long which causes a change of the initial conditions. The cost of the investment is approximate to the actual could be estimated only in the event when the general estimates will be applied for the specific concept of a given investment and its economic review on the basis of the market conditions – and MacroBIM is used for that.
[66] https://www.ribaj.com/intelligence/updates-to-the-riba-plan-of-work-2019-dale-sinclair-gary-clark [Access: May 2020] [76]. DPoW was developed in 2011 and is cyclical updated
[67] Abbreviations mean types of information requirements in the investment processes in building sector and area explained in a further part of the document
[68] Eng.: Pre-qualification questionnaire

5.2.2 Description

Separation and proper treating the phase MacroBIM are of key importance to assure economic safety of the undertakings of every type but especially those in which large funds are involved and which in advance established amount and/or scale of difficulty should constitute the boundary conditions to launch the procedure.

Worldwide there are a few trials recorded to guarantee profitability of the investment, but nowhere it was clearly separated from the building processes. The closest to this is the document developed by government offices in Great Britain in 2014, presenting contractual models of Integrated Project Insurance and Two Stage Open Book. [27]. In addition, King's College London published the document on creating the two stages: or review of the set of bidders and then to conduct proper investment [28].

The Polish strategic development mentioned already in chapter 3.1.1 SARP/GUNB/PZITB of 2015 [19] introduces in fact the request for economic evaluation of the public investments, but without formulating further specific proposals to of implementing steps.

THE MACROBIM PHASE IS A PART OF THE PROJECT PROCUREMENT PROCESS WHICH COVERS DELIVERY OF THE CONCEPT (DESIGN-BUILD) WITH PROPOSED INDICATIVE PROJECT COST BASED ON BENCHMARKS.

MACROBIM CONSTITUTES THE STAGE OF THE PROJECT AWARD PROCEDURE IN PUBLIC PROCUREMENT AND IS NOT DIFFERENT TO THE TRADITIONAL PROCUREMENT PROCESSES. NONETHELESS THE EMPHASIS IS PUT ON THE PROJECT EARLY PREPARATION STAGE SO AS TO ASSURE ITS ECONOMIC SECURITY[69].

MacroBIM consists of the following steps:

- Announcing the procedure with defining needs and requirements of the appointing party;
- Conducting prequalification for selecting a number of participants/bidders defined by the appointing party, who are invited to submit initial offers including the concept of the project delivery with its financial evaluation;
- In the event when the initial offers significantly deviate from the budget, the ordering party should have a possibility to invalidate the procedure;
- Conducting the negotiations between the appointing party and the participants [70] in the scope of the initial offers or the offers submitted during negotiations which include the negotiations of the Target Cost;
- Invitation to submit and submitting the final offers;
- MacroBIM Phase is finished with delivery to the appointing party the conceptual solution (described in a further part of the chapter) with the definition of the Target Cost (see point 5.2.2.3);
- The appointing party assesses both content-related quality of the schematic concept and its economic value. The selected solution (offer) with the Target Cost established is served as the basis for conducting the delivery phase (project and execution).

In order to increase the interest in the procedure, based on the solutions used in case of a competition, the appointing party should foresee the remuneration – in the formula of the return of costs of the participation in the procedure, for the potential lead appointed parties who were invited to submit the initial offers[71]. The return of costs of participation in the procedure is permitted on the basis of the Public procurement law[72], and such a practice certainly will contribute to increasing competitiveness of the procedures.

The concept of each bidder should be developed in the form of cooperation between maximum number of all significant entitis which will be involved in the realization of the building investment, both on the project and

[69] MacroBIM does not proceed the procedure for awarding the procurement (is not the preparatory phase) but it is the part of the procedure.
[70] MacroBIM matches best the mode of negotiations with the announcement.
[71] It is about the return of costs of developing the proposition of the concept and its economic verification in the MacroBIM phase.
[72] art. 134 it. 2, point 13 PPL states that in SWZ the information is defined concerning the return of the costs of participation in the procedure if it is foreseen and in accordance with art. 174 it. 1 point 2 PPL in the procedure of the competitive dialogue in the description of

execution stage (Joint Venture), jointly with the future users, similar as to the multi-lateral contracts for the integrates project-execution phase of the proper investment. Motivation multi-lateral contracts will be however significant as late as in the next phase (delivery).

An additional target of the separated MacroBIM is to establish the principles of cooperation in the evaluation phase with the cooperation schemes in the second realization phase, where the proper management of human resources is already key one for the success of the undertaking.

MacroBIM does not have to be a general obligation but it should be required for the high-risk investments or complex undertakings on the budget exceeding 10 mln Euro.

Taking into account the legal solutions foreseen in the new PPL act, the conducting of the procedure with the use of MacroBIM seems possible with the application of the negotiation procedure with announcement or alternatively a competitive dialogue (152-168 PPL)[73]. The negotiation procedure may be used for the orders covering the building works, supplies or services covering project or innovative solutions as well as in case of orders which due to its their nature, complexity degree or due to the risk connected with the building works, supplies or services may not be granted in another procedure.

The application of the MacroBIM model by the concept presented above may however require legislation changes on the level of PPL in order to allow for the appointing party to invalidate the procedure, in the event when the value of offers significantly exceeds the estimate costs of thecommission[74].

Another reason for separating MacroBIM is the necessity to negotiate the Targe Cost so that it becomes a basic economic criterion of the investment.

The realization of the MacroBIM phase is possible within the public procurement under two conditions:

- The procurement includes as the first stage of the whole investment process the concept of the investment and its economic evaluation based on the concept model of maximum detail of LOD 100 for the massing, LOD 200 for the functional model (more on LOD in chapter 5.8.2.3) and other cost factors. The effect of the MacroBIM phase is the proposal of so-called Target Cost. The completion of the MacroBIM phase does not have to mean automatic passing to another, actual realization;
- In preparing each offer concept and its financial evaluation, if possible, within multilateral cooperation all potential entities should participate involved in the process of delivery of the investment asset, so that economic calculations were most realistic. The current level of technology allows also for creating of energy calculations from the massing and functional models which also is the element of general cost calculation of the life cycle of the asset as a supplementation of the economic offer. These and similar simulations and analyses should usually start each process in the BIM methodology, and not appear just in further phases of the investment processes.

The graphics below presents the example of the conceptual model (cubature and areas of the grouped functions) for the purposes of evaluation of investment cost, based on factors for the MacroBIM phase.

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the needs and requirements one may define the information on level of awards (if foreseen) for the contractors who during the dialogue presented the solutions constituting the basis for submitting offers.

[73] Other modes e.g. competitive dialogue also may be applied here, whereas the phase MacroBIM itself would have to be subject to the modifications resulting from the very procedure of the competitive dialogue.

[74] The PPL provisions strictly define the conditions of invalidation of the procedure – one of the prerequisites is the situation when art. 255 point 3): price or cost of the most favorable offer or the offer with the lowest price exceeds the amount which the appointing party intends to allocate for financing the procurement unless the appointing party may increase the amount up to the price or cost of the most beneficial offer.
In turn, art. 256 allows the possibility to invalidate the procedure before the lapse of the date for submitting the offers if there were circumstances causing that further conducting the procedure is not justified. Art. 255 clearly refers to exceeding the budget by the most beneficial offer.
Art. 256 does not specify whether the invalidation of the procedure due to the change of circumstances is possible before the lapse of period for submitting initial offers or only final ones. For this reason, we recommend considering legislation changes – so that one could invalidate the procedure also after submititng the initial offers.

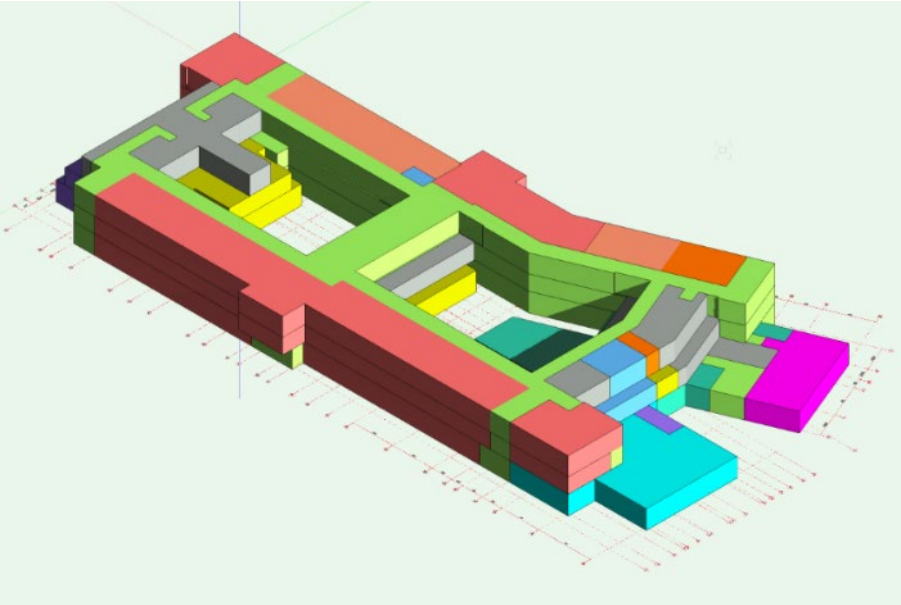


Figure 19: Example of maximum model accuracy for delivery in the MacroBIM phase[75]

This is the recommendation with maximum degree of information saturation, **IT IS NOT RECOMMENDED TO USE MORE DETAILED INFORMATION OF PROGRAMMING THE CONCEPT MODEL FOR INDICATIVE COSTING PURPOSES**. In majority of cases ot would be enough event to have grouped functions in particular storeys of the facility as it corresponds to criteria and methods of estimation (m2, m3, gross/net) from the bulletins of guide prices**.**

The graphic below contains the flow of activities in the investment process with the application of MacroBIM for economic evaluation of the project.

[75] Own 3D elaboration. Concept 2D: arch. Jan Gorgul, Łódź

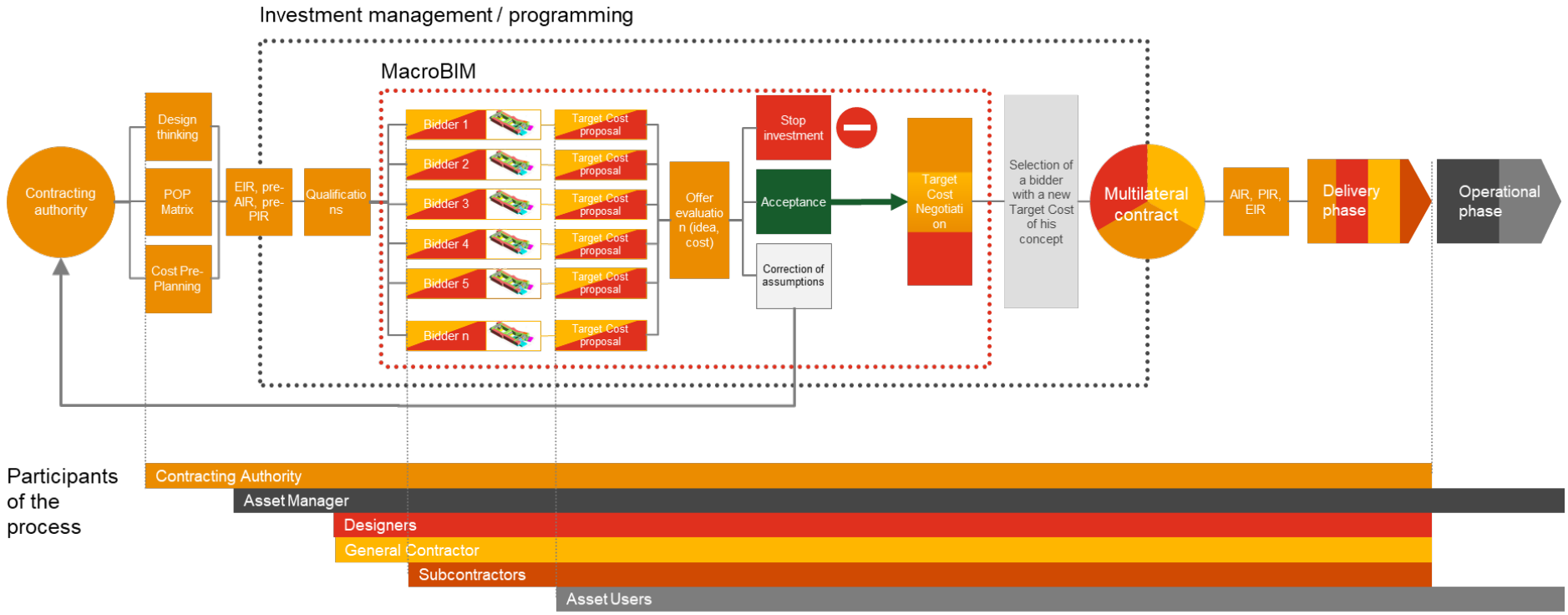


Figure 20: Illustration of the investment process with the application of the MacroBIM phase.

Own study

5.2.2.1 Systems & Design Thinking

The MacroBIM phase should start from structuring the organization of the entities taking part in the initial phase of the investment, first of all from introducing the principles of the Systems Thinking[76] on the intended project. This is the basis of functioning of the integrated organisation, one of the four pillars of the integrated processes, and also a good method to understand the complexity of the investment environment.

Another method to create the corporate governance in building investment is the Design Thinking approach[77]. It is about holistic analysing all factors included in the composition of the developed investment with a participation of the largest number of participants possible taking part in delivery and operation of the future asset. The better the analyses will be conducted the more exact result will be of the evaluation.

For this purpose, there are developed professional tools. The CIFE organization (Center for Integrated Facility Engineering)[78] created the matrix called POP (Product – Organisation - Process)[79] for visual assistance in such an analysis. The matrix has 9 fields in the system 3x3 for the vertical areas crossing (mentioned Product, Organizaton and Process) and horizontal (Function, Form/Structure and Behaviour, namely procedures of activities). The matrix is the product of focusing on the process of creating the solution in the following sequence:

- Understanding the functions, namely which role the asset is to play?
- In what way it is to work, to fulfill expected role?
- What physical structure (form) will fulfill both two conditions?

Below the example of the matrix POP that was presented for the Integrated Team. Separate POP matrices are possible for other participants of investment processes, such as for example business for the appointing party, organizational for the project team and final user.

Table 6. Example of applying the POP matrix for the activities of the Integrated Team[80].

Own study based on [24]

	Product	Organization	Process
Function	What activities creating the quality are to be assured by the asset with high quality?	What goals do we have? How will we achieve them? What do we have to control?	What will we produce (scope, quality)?
Form	What rooms, components and systems should be in the facility?	Who will make decisions as to quality and values? How do we organize them?	What methods will be applied by the team? What will be their steps?
Behaviour	What forecasts will we make? What metrics we use for them?	What will be measurable results for the whole team?	What will be metrics of production and its results?

Another phase of developing the owner's guidelines for creating the types of required information saved in the standard PN-EN ISO 19650-1 with created investment asset also possesses proper and auxiliary visual tools. They come from Lean methodology (referred to in point 5.7.2), but they match functionally the process of making the BIM process real for a specific investment. It is said about the tool called Value Stream Mapping[81], which allows for visual saving and analysing schematic realization procedures in the construction investment. Below is the list of exemplary icons presented (not standardised yet) and symbols for creating diagrams for

[76] https://pl.wikipedia.org/wiki/Systems_thinking [Access: May 2020]
[77] https://pl.wikipedia.org/wiki/Design_thinking [Access: May 2020]
[78] https://cife.stanford.edu [Access: May 2020]
[79] https://iglcstorage.blob.core.windows.net/papers/attachment-30b78560-b1d5-4c64-b478-acaa815e4bec.pdf [Access: May 2020] [78]
[80] Integrated Team means all participants of the investment conducted in the BIM methodology. Full definition in the Dictionary.
[81] One of the Lean tools, discussed in point 5.7.2.3

investment programming in the MacroBIM phase. This is another evidence that in the integrated processes the elements penetrate each other and overlap.

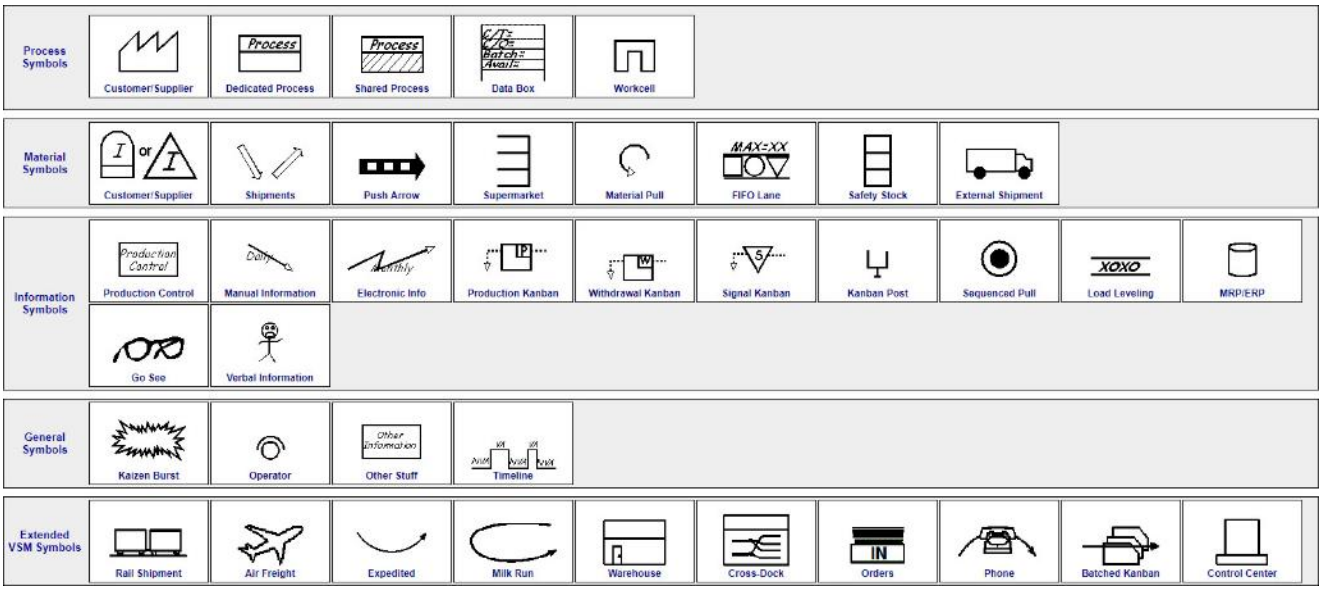


Figure 21: List of icons and symbols for preparing graphic for Value Stream Mapping.[82]

5.2.2.2 Appointing authority's requirements (SWZ + BIM)

As part of this study there provided are templates of documents to be developed by the appointing party. The templates are based on the PN-EN ISO 19650-1:2019 standard recommendations and they constitute the whole package of requirements of information which the appointing party will prepare before the commencement of the project.

The information requirements should already be presented to the bidders in the MacroBIM phase. Their form consulted with the lead appointed party is the basis of the required information on the asset in the process of its creation and delivery, thus in the delivery phase.

5.2.2.3 Target Cost

The idea and principles of extrapolation of the Target Cost, thus the basic economic criterion of the investment, were presented graphically best in the presentation of the Haahtela team on the forum organized by Lean Construction Institute in January 2016. Below own graphics on the basis of the Finnish source[83]:

[82] https://4improvement.one/knowledge/tools-techniques/25-problem-analysis-tool/153-value-stream-mapping [Access: May 2020] [79]
[83] http://p2sl.berkeley.edu/wp-content/uploads/2016/03/2016-01-2829-LDF-2016-1-Haahtela-1.pdf [Access: May 2020] [29]

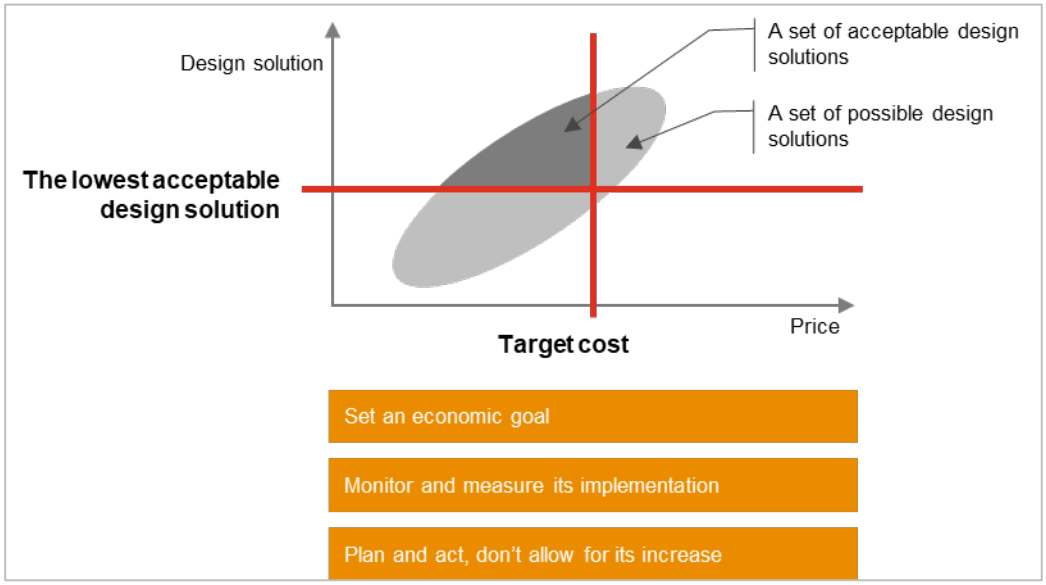


Figure 22: Diagram of extrapolation of Target Cost from among available project solutions. [29]

TARGET COST SHOULD BE THE STARTING POINT FOR EACH INVESTMENT PROCEEDED IN THE BIM METHODOLOGY.

From the possible base of project solutions for the project phase only those are selected and assessed which remain after putting on their placement two criteria: minimum quality of the project solution and the maximum Target Cost assumed in the process of evaluation of the design concept.

The evaluation of the concept assumes the guide calculations for m^2 of the gross/net functions, m^3 cubature, unit calculations, others possible to obtain from the massing models (without any definition of the building parts, or openings) and lists of groups of functions (without division into individual allocation of rooms). The factor-based cost is extrapolated in the minimum-maximum brackets (the price lists may be helpful here, containing guide costs) and then compared by the bidder with the market costs for the investments of a similar type. The review contains the proposition of the Target Cost of the investment, presented as the final product in the MacroBIM phase of the procedure. In case of accepting the offer, Target Cost is then established in negotiations with the appointing party as the basis for further procedure. This is a project approach coming from the established cost and not calculating the cost for the resulting project.

So that the proposal was realistic, it must take into account not only the project solutions but also execution ones, organisation of the construction site and operation costs as well. Thus, it is recommended to create multi-functional teams preparing the cost offers in the MacroBIM phase.

As a target for implementing BIM in Poland it is recommended to accept the gradually other contracts than „design and build" or „build" while the latter ones are not recommended from the perspective of the service of the Target Cost as they do not assure the full cooperation and seeking the common goal for all participants of the investment[84] . It is said about multi-lateral contracts created especially for BIM.

The task of the appointing party at the completion of the MacroBIM stage is:

- Either to reject the idea of realizing the investment when the proposed Target Cost by the bidders in the MacroBIM phase exceeds the financial investment possibilities of the appointing party (not forecasting the improvement of the Target Cost during negotiations);

[84] The purpose of the investment in the multi-lateral contracts of a Joint Venture type is to deliver the assetwith the highest possible quality with the preservation of Target Cost, date of delivery of the asset and full cooperation and transparency in the financially motivated environment with the mutual liability waivers. This then means one goal for all.

- Or start negotiations of the final Target Cost, which will be applicable for the delivery phase of the investment realized by the multi-functional asset creation and delivery teamwhich won the procedure in the MacroBIM phase.

In chapter on Lean (point 5.7) the principles of monitoring the Target Cost were presented for preventing its increase.

5.2.2.4 Contracts for BIM

The agreements concluded on the basis of the PPL provisions are of civil-legal nature (art. 8 it. 1 PPL). The abovementioned means that the agreement for the public procurement is subject to contractual freedom resulting from art. 353(1) of the Civil code with limitations resulting from the PPL i.e. form or principles of changing the provisions of the agreements for public procurement.

Despite the mentioned principle of contractual freedom of the parties to the action public procurement are as to the principle the nature of adhesion agreements the provisions of which are shaped to the benefit of the party which is the author of the agreement (appointing party here). The problem of the lack of assurance or at least preserve the contractual balance of the parties appears irrespective of the used model of the agreement both on the ground of the agreements prepared in whole independently by the appointing parties for the purposes of realizing the specific investment as well as on the basis of the agreements based on contractual patterns – e.g. contractual patterns FIDIC – adjusted to the needs of a given investment. Similarly, preservation of the contractual balance of the parties one may observe irrespective of the used model of realizing the building intention in the "build" formula (the lead appointed party performs the facility on the basis of the project documentation delivered by the appointing party) or "project and build" (for preparing the project documentation and performing the investment the contractor is responsible)[85]. In the context of the above notes positive one should assess the regulations foresee in art. 431 and subs. of PPL from which, i.a. the obligation of cooperation of the parties results in performing the agreement, the prohibition to use abusive clauses or the obligation to define the principles of review of the contractor's remuneration.

THE PROJECT DELIVERY MODEL BASED ON THE TRANSFER OF ALL DESIGN AND CONSTRUCTION RISKS TO THE CONTRACTOR, SHOULD NOT BE A PRACTICE MODEL FOR BIM-BASED INVESTMENTS.

In its assumption BIM is to support the realization of the investment based on integrated and mutual cooperation of the parties and as it is indicated by the research the largest benefits was brought about by the model of realizing the investment based on the earliest involvement of all stakeholders [30]

From the organizational and functional point of view, modelling the information may assure better coordination and monitoring in all phases of realizing the investments starting with planning to the phase of awarding the procurement and realizing it. What is important, it may limit the necessity to make changes and modifications of workmanship which may have critical meaning in the context of cooperation of the participants of the investment process. For this reason, the contractual provisions are of key importance for using BIM, if they respectively settle, i.a. the issues of: (i) dates with reference to transferring and approving of the project information and other data; (ii) detecting collision, earlier warning and risk management; (iii) intellectual property right[86] (chapter from the book [31]) As the practice shows this is the introduction of changes in the course of realization of the investment and as a result the creation of delays and increase of costs of realizing the investment which raises the largest controversies and is the reason for disputes between the investor and the contractor.

[85] Proposed multi-lateral agreements of Joint Venture type clearly settle the liability of the parties on the basis of the shared risk but also shared profits. The basis for BIM is cooperation and this can be achieved only by procedural and financial transparency and by incentive agreements. Unilateral nature or failing to balance the liability always results in searching for the guilty person and as a result antagonism of attitudes. This is contrary to BIM principles.

[86] https://iris.unito.it/handle/2318/1716305#.XsL7ey-w2L5 [Access: May 2020] [33]

The contracts for BIM are characterised with rejecting the antagonist positions and accepting the cooperative model of functioning. For this purpose, a few elements of such investment agreements are necessary:

- Multi-lateral nature thus one common agreement for all parties;
- For avoiding of conflicts and supporting cooperation: introducing the mutual liability waivers (except for claims of third persons and purposeful guilt);
- Introducing a basic criterion of economic evaluation of the investment in the form of Target Cost in the MacroBIM phase, monitored then for the whole duration of the investment;
- Introducing the incentive element in the form of the financial pillow to share between the parties (members of the Core Group or another disposition) in case of delivery of the asset on date and in the Target Cost or to cover loses in case of failure to maintain these requirements[87];
- Introducing commonly defined Risk Register, methods of managing this catalogue and methods of common removal of emerging risks;
- Introducing the obligation to establish the Core Group, managing the investment in the phase of creating and delivery of the asset consisting of the representatives of the representatives of the main contractors (project + construction) and the appointing party.

Such integrated agreements create the system of shared risk, the purpose is to decrease the total risk of the investment realization. There are examples of such contracts. The most known include:

- IPD – Integrated Project Delivery (by Hanson Bridgett LLP from the U.S.A.[88] – Standard Multi-Party Agreement);
- PA – Project Alliancing;
- CLP – Cost Led Procurement;
- IPI – Integrated Project Insurance;
- 2SOB – Two Stage Open Book [27];
- EBP – Early BIM Partnering;
- AIA C191/195 – of AIA family (American Instituteof Architects);
- Consensus DOCS 300.

There are also a few other proposals of the agreement form, close to the optimum solution of Joint Venture, and thus directed to the realization of a common goal and to achieve common profits or covering common losses, limiting at the same time making somebody guilty for failure in exchange for common liability. This is more important because the standards of conditions of the processes should not support only the appointing party – equally important is to build motivated and committed teams. The motivation can be achieved while realizing human needs by the Maslow pyramid mentioned in chapter 0 and including the participation in profits of the whole undertaking (see the type of division in the footnote).

This factor is especially important in Poland, where the fees for the projects and profits of the contractor companies dropped much lower than in standards of developed countries. The project remuneration often fluctuates below 1% of the whole investment which is not a good prognosis for introducing BIM in Polish investments, and not only public ones. Financial motivation factors of integrated contracts will allow in part to level disproportions also in case of profits for contractor companies[89].

[87] From some world publications there is the suggestion to divide the motivation pillow (in case of its usage): 40-50% appointing party, 40% GW, 10-20% branch designers but this depends on many factors. It is recommended to establish such frames at the beginning of each investment.
[88] https://www.hansonbridgett.com/Practices-Industries/construction/ipd-bim [Access: May 2020]
[89] The example of the disproportions in profits of the parties, taking part in the building investments from the point of view of contractor companies:

Currently applied agreements in Polish investments based on FIDIC standard are not allocated for the realization of the integrated investments as they do not assure integration due to the limitations protecting both parties but mainly the appointing party. These are the agreements of antagonist type, not favorable for building trust nor transparency irrespective of the fact which of these FIDIC forms is selected to conduct the investment. In the meantime in the world reports on the investment processes conducted and completed in the BIM methodology the factor of trust is in the first place on the listof the positive experience gained (e.g. [90] or [32]).

Trust between the parties to the contract based on the coordination of activities and systems of reacting and risk management leads to larger effectiveness of BIM and the realization of the investment itself[91].

The MacroBIM phase refers to conceptualization of assumptions of the appointing party and their economic evaluation without further project studies let alone the execution ones. The recommended form of the multi-lateral agreement will be helpful for the bidders in the MacroBIM phase to collect the contribution and opinion of specialists who may jointly use their experience for preparing the concept of the investment and its Target Cost. Such forms of multi-lateral agreements that will appear in the future as the MacroBIM phase and the investment itself in the BIM methodology are the new propositions for the Polish construction market.

Establishing the contract patterns or the model of the agreement for the BIM investment will play an important role in the process of promoting the model of the investment realization. As it is indicated in the literature the issues concerning the lack of contractual patterns and standards in the investment process constitutes one of the main legal barriers in using the BIM model[92]. For this reason, it is necessary to develop the contract patterns or at least model contractual clauses, which will be placed and applied in the public procurement contracts.

The amendment to the Building Law, with the projected entrance into force in September 2020, additionally will strengthen the need to separate the economic verification phase of the investment as by means of formal requirement to deliver three types of project: project of area management, building project and technical project the project phase will be significantly extended and its cost, but it will be the proposal aiming at achieving the increased quality and exactness of the project. It will allow automatically for better estimation of the profitability of the investment. This is approximate to the regrouping of the works to the initial stages of the investment consistent with the BIM philosophy. Delivery of partial studies Data Drops typical for the BIM methodology will facilitate earlier calculations, based on factors. In case of applying the traditional method to the investment processes, much time will be needed to issue the first official project study which will prevent for making profitability calculations on time, before the investment process will be launched for good.

5.2.2.5 Trainings

It is suggested to conduct the trainings for the phase of the evaluation of the investment, covering the methods of estimating the benchmark costs on the basis of the block models and functional systems, as well as extrapolation of life cycle costs of the facility for the period of its operation.

In the future the function will be taken over by the role of cost estimator in BIM methodology, acting on project models.

http://www.inzynierbudownictwa.pl/biznes,raporty,artykul,firmy_budowlane_IV_kwartał_z_rzędu_z_ujemną_rentownością,11514 [Access: May 2020] [80]

[90] https://www.sciencedirect.com/science/article/pii/S2090447920300344?via%3Dihub [Access: May 2020] [61]

[91] https://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0001521 [Access: May 2020] [68]

[92] https://www.researchgate.net/publication/328454349_A_critical_review_of_legal_issues_and_solutions_associated_with_building_information_modelling [Access: May 2020] [69]

5.3 Delivery phase

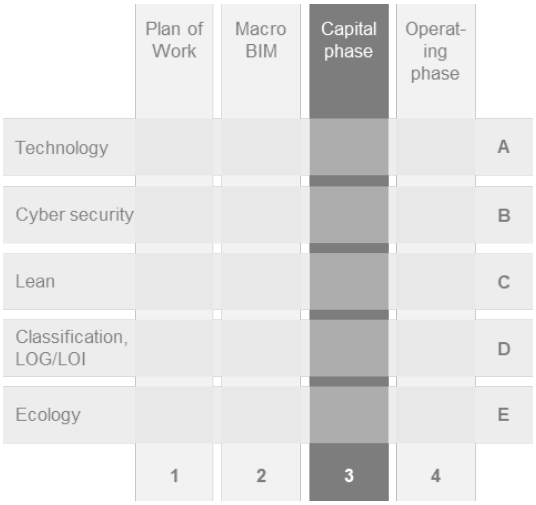


Figure 23: Delivery phase - third element of the matrix for temporary investment phases.

Own elaboration

5.3.1 Legal-normative system

- The Act of 11 September 2019 Public Procurement Law (**J. L. 2019, it. 2019**), taking especially into account art. 101-103 of the new PPL referring to preparing a description of the subject of procurement i.a. for building works including by means of referring to the Polish Standards transposing the European standards and international standards; art. 239-247 of the new PPL referring to the criteria of offer assessments;
- The standard of the series ISO 19650 on managing the information with the use of BIM: **PN-EN ISO 19650-1:2019** - Concepts and principles, **PN-EN ISO 19650-2:2019** –Delivery phase of the asset. Technological Committee TK59 of the ISO organisation published, based on British patterns PAS and BS series 1192 (on service of the building processes in the BIM methodology) a series of world standards ISO 19650, with parts devoted to the information management on created asset in the processes.

  The delivery phase is the phase of "production" and transfer of the asset in the design and implementation process and it is the topic of the chapter. One of the characteristic features if the series of standards is to introduce so called „Risk register" namely central catalogue developed of possible risks for the specific investment. The risk register also appears in the standards ISO Guide 73:2009, ISO 31000:2009, described below thus this is fluent continuation of the development of investment risk management in building sector. In connection with the multi-lateral contracts for the integrated investment it will allow for optimum and common management of the risk situations for the investment, which in turn will allow for shaping the future (although present in the world) Joint Venture type contracts with waiving mutual claims by the parties to the contract;
- The **ISO/IEC 31010:2019** standards on risk management (Risk management - Risk assessment techniques). Derivative older standards are: AS/NZS ISO 31000:2009 (Risk management framework) and ISO Guide 73:2009 (Risk management).

5.3.2 Description

When the evaluation phase of MacroBIM is successful, one may start to launch the financial funds for the realization of the design.

PPL regulations are not the obstacle to apply BIM in the procedure for awarding the public procurement. Irrespective of the type of the procurement (service or building works) and irrespective of the formula of the

project delivery, the basis for the application of BIM and defining the obligations connected with the application of the formula shall be the requirements defined by the appointing party (owner) in the documentation for awarding the procurement.

Legal basis to formulate such requirements will be:

1. art. 99 PPL in accordance with which the appointing party, i.a.:

- describes the subject of procurement in a definite and exhaustive manner, by means of finally exact and understandable definitions, taking into account the requirements and circumstances which may have an influence on preparing the offer.
- defines in the description of the subject of procurement required features of deliveries, services. Or building works – what is important these features may refer in particular to a defined process, method of production, realization of required supplied or building works or specific process of their life cycle, even if the factors are not their specific element, provided they are connected with the subject of procurement and proportional to its value and purposes.
- may define in the description of the subject of procurement the necessity to transpose the author property rights or granting the license.

2. art. 101 PPL – in accordance with which the subject of procurement is described, by means of (i.a.):

- definition of efficiency and functionality requirements, including environmental ones;
- referring to the required features of the material, product or service, including referring to:
  - Polish Standards transposing the European standards,
  - standards of other membership states of European Economic Area transposing European standards,
  - international standards,
  - technical specifications the compliance of which is not obligatory, accepted by the standardization institution, specialized in developing technical specification for repeated and constant usage,
  - other systems of technical references established by European standardization organisations;
  - referring to the standards, European technical assessments, technical specifications and systems of technical references, and by means of referring to the requirements of effectiveness or functionality in the scope of selected features.

3. art. 102 it. 1 point 10) – 13) PPL – in case of procurement for the construction works the appointing party defines in the description of the subject of the procurement for the construction works required features of the material, product or services corresponding to the intended purpose by the appointing party, which may refer in particular to:

- defined principles concerning projecting and cost-estimating;
- testing conditions, control and collection of building facilities;
- methods and technics of construction;
- all other technical conditions.

4. art. 103 PPL – the procurements for the building works are described by means of project documentation and technical specifications of performing and collecting the building works, whereas for the project delivered in the formula „design and build" the appointing party describes also the subject of procurement by means of the functional-utility program.

On the basis of the provisions of PPL this is the appointing party who define the requirements concerning the subject of the procurement, significant features which are to be fulfilled, including also requirements concerning projecting or other technical conditions. One should pay attention to the fact that the provisions defining the description of the subject of the procurement, in particular in the scope of building works (art. 102 it. 1 PPL), have the nature of open catalogue – which is indicated by using the formulation „in particular". At the same time, the appointing party may define independently additional requirements and parameters, if the basic

principles of the description of the procurement are not infringed referring to the definite and exhaustive requirement in the manner which does not pose obstacles to fair competition (art. 99 PPL).
What's more, on the basis of art. 101 PPL the requirements concerning the subject of the procurement – in the respect of the required features of the service – may be defined by referring to the requirements of the Polish Standards transferring European standards, international standards and even technical specifications the compliance of which is not obligatory, if they were accepted by the standardization institution, specialized in developing technical specifications for repeated and constant usage. Describing the subject of procurement by referring to the standards, technical assessments or the technical specifications and systems of technical references the appointing party is obliged to indicate that it allows for solving equal solutions to those described.

The regulations referring to the description of the subject of procurement constitute a key, although not only one factor which may have the importance dissemination of BIM. Irrespective of the requirements concerning the very description of the procurement for distribution of application of the mode one should take into account also the fact with which criteria of assessment the appointing party will be directed to make the selection of the best offer. Implementation of the BIM methodology assures realization of the public procurement, reduces the risk and costs and also information asymmetric, therefore usage of BIM methodology in the procure for awarding the procurement may have strategic meaning, inter alia, for the assessment of the most favorable economically [33].

The criteria for awarding the procurement constitute one of the key issues both on the basis of the Directive 2014/24/UE and Polish regulations of the public procurement, in which the emphasis is put on the non-price assessment criteria of offers and granting the priority to the concept „best relation of quality to price". As it is indicated in the introduction to the Directive 2014/24/UE, „decision on awarding the procurement should not however be based on exclusively on the non-cost criteria. The quality criteria should therefore be completed with cost criteria, which by the opinion of the appointing institutions could be the price or the approach based in cost effectiveness, for example costs of life cycle" (com. motif 90 and 92 the introduction of the directive 2014/24/EU). The approach based in cost effectiveness should be understood here as internal costs, concerning directly a given order and external costs understood as, for example costs connected with the influence of a given procurement on the environment, including also factors other than price, which will have influence on complete value of a given procurement, both in point of view of the appointing institutions and beneficiaries of a given procurement, which may be included as cash value. The example of such approach could be art. 67 it. 2 of the Directive 2014/24/UE is showed directly to the costs account of life cycle.

Following the regulation resulting from the provisions of the Directive 2014/24/UE on the basis of the provisions of art. and subsequent of PPL the criteria are indicated of choice of offers most beneficially based on the quality criterion of price or cost. The quality criteria which may be used by the appointing party may refer to the quality understood as, i.a. technical parameters, social aspects, environmental aspects, including energetic effectiveness of the subject of procurement, innovative aspects; organization, professional qualifications and experience of persons appointed for the realization of the procurement. If they can have more significant influence on quality of the procurement, post-sale service, technical assistance, conditions of supply, such as date, method or time of delivery and construction time.

In the context of using and promoting the BIM model, special attention should be paid to the possibility to use quality criteria of selecting the offer connected with innovative aspects, environmental ones and professional qualifications and the experience of the persons appointed for the realization of the procurement.

The quality criteria listed above are only of exemplary nature and their catalogue on the basis of the law provisions are open. It means that the appointing party may apply other quality criteria provided they will be connected with the subject of procurement and they will not refer to the competence of the contractor (or lead appointed party) himself, and in particular its economic, technical and financial reliability.

What's important one of the criteria of the most beneficial offer mat constitute the criterion of cost based on method of cost effectiveness being the account of life cycle costs. In accordance with art. 245 PPL it may cover in a proper scope some or all costs incurred during the life cycle of building works. In particular there can be costs incurred by the appointing party or other users in the whole period of „life" of the project, e.g. costs of

usage, consumption of energy and other resources and costs ascribed to external effects, i.e. costs of issue of greenhouse gases and other pollutions and others connected with mitigating of climate changes .

Long-term practice of using the criteria of assessment of offers on the ground of public procurement indicated definitely that the preferred and favorable criterion of selecting the offer by the appointing parties is the price. [Office of Public Procurement, Report concerning criteria of offer assessment – *influence of changes introduced with the amendments of the Public procurement law of 29 August 2014 and of 22 June 2016 for using non-price criteria of offers in procedures of public procurement,* Warszawa, May 2017]. As late as legislation changes introduced in the act in 2014, ant hen in connection with implementation of the Directive 2014/24/EU, in 2016 from which the limitations resulted in using the assessment criteria of offers or criterion with the weight higher than 60% [presently art. 246 it. 2 PPL] allowed to popularize the usage of the non-price criteria. Before the change of law made in 2014 the price criterion – as the only one criterion of assessing offers was used in about 76% proedures for building works above the EU thresholds, after the change of law the interest amounted to only 15% in 2015, a and after amendments in 2016 - 10%.

As it results from the statistics indicated in the above report, the appointing party „is willing" to use other criteria than price – which however results from the obligation imposed with law provisions. The same statistics shows also that despite broad range of assessment criteria which may be applied most often „simple" criteria are used i.e. the „date for completion of the procurement", conditions or dare of guarantee and terms of payment.

Prooting the use of BIM will require putting larger emphasis on using non-price criteria connected with BIM as the element of the procurement or criteria of costs, which may optimize by using BIM methodology especially in the context of costs of project life cycle.

As it was indicated above the provisions of PPL oblige the appointing parties to use the offer assessment criteria, nonetheless however the previous practice using non-price assessment criteria shows that it is preferred to use simple criteria used above. What's more in practice of awarding procurements the application of non-price criteria, i.e. shortening the delivery programme (with minimum period defined by the appointing party) or extension of the guarantee period (with the date maximum indicated by the appointing party) leads to the situation in which all contractors (potential lead appointed parties) declare analogue dates and at the same time they obtain identical points within assessment criteria. Therefore, the sole criterion which decides about selection of the offer is price.

IN THE FIRST STAGE OF IMPLEMENTING BIM IT IS RECOMMENDED TO DEVELOP A DRAFT PROCUREMENT POLICY UNDER THE PUBLIC PROCUREMENT LAW, WHICH DETERMINS THE OBLIGATION TO APPLY BIM METHODOLOGY IN THE PUBLIC PROJECTS WITH ESTIMATED VALUE EXCEEDING 10 MILLION EURO, COMISSIONED BY THE INSTITUTIONS OF GOVERNMENT ADMINISTRATION, AS WELL AS THE TOOLS TO ENFORCE AND PROMOTE THE USE OF BIM METHODOLOGY.

ADDITIONALLY, IT IS RECOMMENDED TO OBLIGE THE APPOINTING PARTIES TO APPLY NON-PRICE CRITERIA OF THE TENDER ASSESSMENT CONNECTED WITH BIM WITH THE MINIMUM WEIGHT OF 20%.

IN THE SECOND STAGE THE OBLIGATION TO USE THE BIM METHODOLOGY IN PROJECTS WITH ESTIMATED VALUE EXCEEDING 10 MILLION EURO ALL PUBLIC APPOINTING PARTIES WILL BE COVERED.

EVENTUALLY, THE OBLIGATION TO USE THE BIM METHODOLOGY WILL APPLY TO ALL PUBLIC APPOINTING PARTIES IRRESPECTIVE OF THE PROJECT VALUE.

Such legislation similarly as defining maximum threshold of assessment criteria (60%) should bring positive effect in distribution of criteria connected with BIM.

As to the principle the catalogue of non-price criteria is the open catalogue, and within, the appoiinting party independently select the type and weight of the non-price criterion. As the practice shows in the previous procedures also for awarding the public projects with the use of BIM the dominating criterion refers to the staff experience. In order to diversify BIM-related criteria, consideration should be given to identifying applicable criteria by promoting good practices and model documents. Alternatively, legislative changes should also be considered using the implementing rules set out in Article 244 Public Procurement Law. In accordance with the

provision indicated, the competent minister for economy defines by regulation others than the price, criteria of offer assessment, which are applicable with reference to some types of orders and method of describing and assessing the criteria. The purpose of defining the criteria on the level of execution law requires however further analysis, taking into account the nature of the orders based on BIM e.g. in the context of using as the criteria the cost assessment, including costs of the life cycle.

5.3.2.1 PIR / OIR / EIR / AIR[93]

The abbreviations indicated in the title mean the lists of structurised information required by the appointing party in the area of the project information (PIR – Project Information Requirements), organizational ones (OIR – Organization Information Requirements), the very process of information exchange on the future asset (AIR – Asset Information Requirements). They are saved by the appointing party and transferred to the delivery team as the information requirements in the whole period of project delivery.

The scope of information for particular forms of requirements is described in the texts of the series of PN-EN ISO 19650 standard, and more careful developed in another part of this project.

All these sets of information relate to unified system with both digital products of the investment in the BIM methodology: PIM (Project Information Model) and AIM (Asset Information Model). Their mutual interdependence will be presented by the graphics below, developed based on the PN-EN ISO 19650-1:2019 standard:

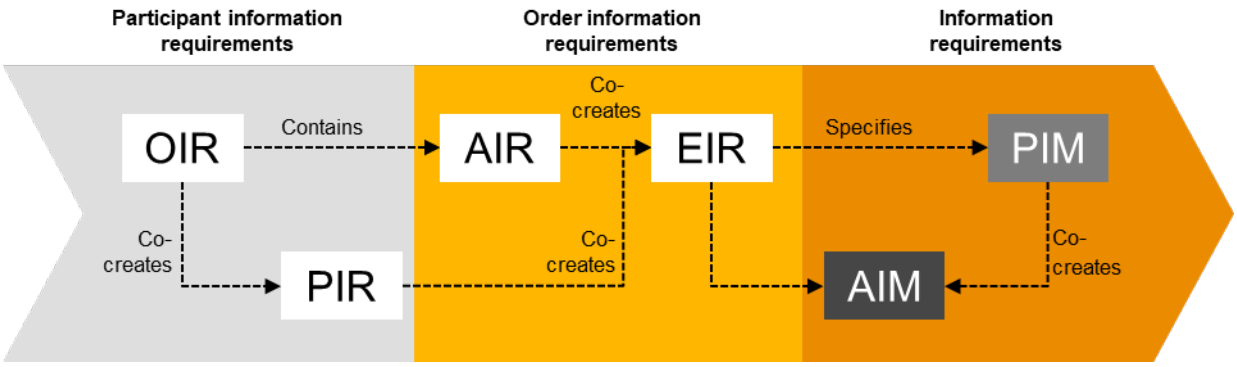


Figure 24: List of information requirements for the investment process in BIM methodology[94]

The requirements of the information of participants of the investment process are not created only on the side of the appointing party. The PLQ tool (Plain Language Questions, namely the questions asked with a plain text) is the method with which the contractor (lead appointed party) may obtain from the appointing party the answers for formulating their own requirements, organizational (OIR), and project (PIR) ones. Only when the sets of requirements are processed to OIR, PIR and AIR for the whole investment. Also, tools are created which register all these documents in the form of contents of online portal, further on allowing to control the consistency of the investment proceeded with the initial conditions created in that way (SHIFT[95]).

The investment process in the BIM methodology is a cooperating one and it is characterised to a large extent by top-down activities („pull"), and bottom-up („push"), to create the atmosphere of transparency, favorable for building the trust and generating the commitmentof the whole Integrated Team.

[93] Types of requirements hidden behind the abbreviations are developed in other documents of the project („Managing the building investment in BIM methodology – proposition of document templates")
[94] Own elaboration on the basis of 19650-1 standard and portal: https://medium.com/@davis_96496/construction-stop-creating-oirs-and-project-requirements-in-word-and-excel-your-project-depends-ba30e89ce1ed [Access: May 2020] [81]
[95] https://medium.com/@davis_96496/construction-stop-creating-oirs-and-project-requirements-in-word-and-excel-your-project-depends-ba30e89ce1ed [Access: May 2020] [81]

5.3.2.2 PIM – Project Information Model

This is the final, digital product of information in project phase, used in the process of project delivery to build the asset. PIM constitutes the set of the collected information during the project phase, completed with the data from the workshop models of subcontractors (appointed parties) and suppliers and own contribution of (general) contractor (lead appointed party) is therefore a rich information resources of each investment. PIM is further on the base AIM, namely cleaned from unnecessary information from the phase of the asset creation and delivery and enriched with the model operational data intended for managing the built asset in time of its operation.

The form of PIM transferred to the appointing party is a model of geometry in the suggested, world strategies of BIM (e.g. Czech one), IFC format with alphanumeric information or integrated with geometry or which is another developmental rail, separated from each other for the management of it without the need to deal with geometrical data. In additional there can exist additional forms of data in it in the form of video files or material samples in accordance with the specification of types of information from the PN-EN ISO standard series 19650, saved in the CDE platform of a given investment.

The degree of absorbing the PIM information by LOD achieves the level As-Built, namely – depending on the project arrangements– LOD 500 or LOD 600 (more on LOD in part: Classifications, point 5.8.2.3.)

5.3.2.3 MIDP / TIDP

These are the plans for delivery of the information from the contractor (lead appointed party, concerning the stages of the project-execution process, recorded as the schedule of Master Information Delivery Plan and plans of particular Task Information Delivery Plans. These requirements should be started also by the whole Integrated Team and by the Task Teams. The method of organization of the Integrated Team and task teams and possibilities of their visualization were discussed in the chapter devoted to Lean – point 5.7.2.

General plan MIDP and task plans TIDP should be coordinated with the set of schedules of the LastPlanner® System due to better adjustments of Lean plans to the execution possibilities of the task teams on one hand but on the other with reference to the control of punctuality to perform the whole investment, for which MIDP is responsible. In the best case MIDP becomes the Master Plan of the Lean ecosystem. This is the activity which integrates the processes, another of the four pillars of the BIM methodology.

FROM CREATION, ACCEPTANCE AND COMMENCEMENT OF THE MIDP REALIZATION, THE PROPER PROCESS OF WORK-FLOW IS STARTED IN THE INTEGRATED METHODOLOGY, AND THE TIDP PLANS ARE ITS ITERATIONS. THEIR CONDITIONS IS THE STRICT COOPERATION OF ALL STAKEHOLDERS OF THE PROCESS, AT BEST IN A CO-LOCATION, NAMELY IN ONE ROOM, CALLED THE BIG ROOM. THIS IS A LOCATION, IN WHICH THE PROJECT TASKS ARE RESOLVED COMMONLY AND IN REAL TIME.

Division into traditional phases of the building investment gives place to the sequence on providing the information on the created assetwith regular transfers of partial effects in the form of so-called Data Drops[96], irrespective whether this is the stage of desig, or the stage of construction. It corresponds to the type of work in the Agile methodology (more on Agile in the part devoted to Lean – point 5.7.2.8). The scheduled Data Drops should be proposed by the contractor (lead appointed party) in the contractual BIM Execution Plan (BEP) on the basis of the expected sets of information by the appointing party for specific purposes.

The organization on the execution level is the bottom-up method of meeting the imposed top-down requirements and thus adding to this the practical understanding of the tasks to perform. Only in this manner one may create a common platform integrating all parties to the processes. In the BIM strategy for Germany such an integration is called convergence (focusing interests and purposes in the common form of the information plane), and the information exchange itself may assure the commitment of the teams and thus gain the trust.

[96] Required in the set of preparatory documents of the investment periodical supply of specific sets of information on the asset on defined moments of the investment process, so called milestones. Full definition in the Dictionary.

5.3.2.4 Pre-contract BEP (BIM Execution Plan)

Pre-contract BIM Execution Plan (pre-contract BEP) is the first contribution of the delivery team (project + construction) to fulfill the requirements of the appointing party, entered in SWZ with conditions of BIM (previous British name is EIR – Employer's Information Requirements – presently accepted one in the form for another marking by the BIM standards from the ISO 19650 series) and BIM Protocol. The templates of such documents are the subject of another part of this project („Managing the building investment in the BIM methodology – proposal of templates of documents").

5.3.2.5 Risk Register

This is an optimum form of managing investment risks in contracts, not only integrated. The risk register is created as a tabular electronic catalogue with a participation of all parties to the investments and due to this it constitutes a complete set of possible threats, entered from all possible perspectives. Additionally, it's the formulation from the ISO norms on risk threat which were indicated in point 5.3.1.

A cooperative nature of contracts in investments of BIM type is able to assure in addition collective risk management within common liability. The condition for the success is the proper contract environment, because only in the form of assured, common, economic interest there may be a willingness of close cooperation in removing emerged threats.

5.3.2.6 Automation and prefabrication

An economic goal of the digitalization of the building processes is automation of products based on production processes in the industry sector. There are two methods of realizing this assumption:

- prefabrication –available and used method in construction sector in Poland already now but still not in the scope in which it is possible;
- print of 3D facilities – the method not realized presently in Poland in building sector, used by some countries in order to print building facilities e.g. People's Republic of China.

The need for automation of the building processes resulted in the method of design strictly for the purposes of fabrication to avoid losses in production processes in construction sector. The method is called DfMA (Design for Manufacture and Assembly)[97], namely designing with the thought of building production and assembly. It involves simplifying the design of components of complex systems so that they could be created in a simple manner and then put up in the created building facility. At the same time, it is one of the Lean Manufacturing tools (slim production).

Because the DfMA method is implemented worldwide, Asian countries, for example, especially Singapore, (Hong Kong or Malesia) advanced the automation of construction even more. In Singapore, a method of automation was developed called PPVC (Prefabricated Prefinished Volumetric Construction)[98], involving prefabrication and equipping the elements, being the whole office or residential units. Its basis is, first, close modularity.

The graphics below present 3 PPVC phases from development from Hong Kong: a phase of default casting of the element, then equipped with installations and building elements and finishing phase, still before the transport to the construction site. One of the difficulties in such cases is the necessity to adjust to the regulation, concerning the transport of such volumetric elements to the place of assembly.

[97] https://www.designingbuildings.co.uk/wiki/Design_for_Manufacture_and_Assembly_(DfMA) [Access: May 2020] [82]
[98] Eng. PPVC (Prefabricated Prefinished Volumetric Construction) –

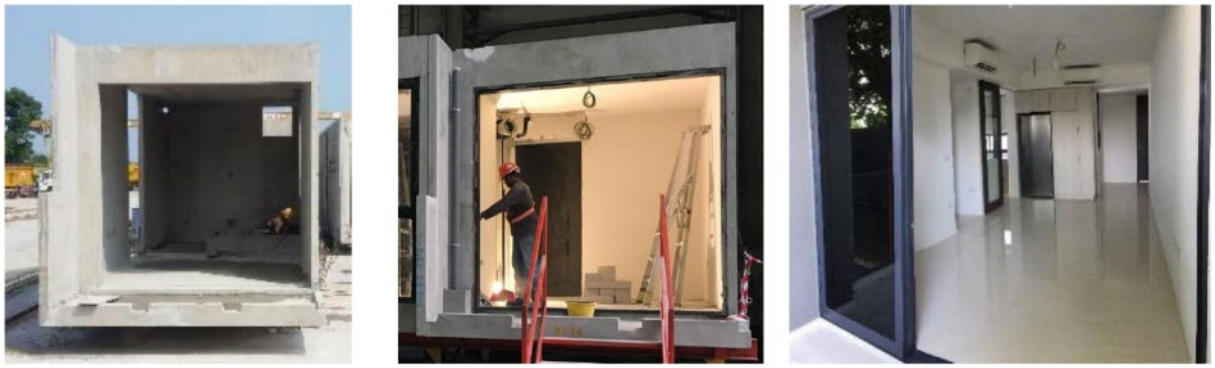


Figure 25: Three stages of prefabrication of the large-space element PPVC (HongKong). [34]

In Singapore, this is a standard method of building processes, whereas the requirements posed by the regulations assume for the erected residential buildings level of minimum 65% of the PPVC application.

The temporary savings expected in this way are presented on the graphics by the representative from the Singapore Institute of Technology. The first red beam means traditional approach to the facility construction, second – presents the approach by PPVC method.

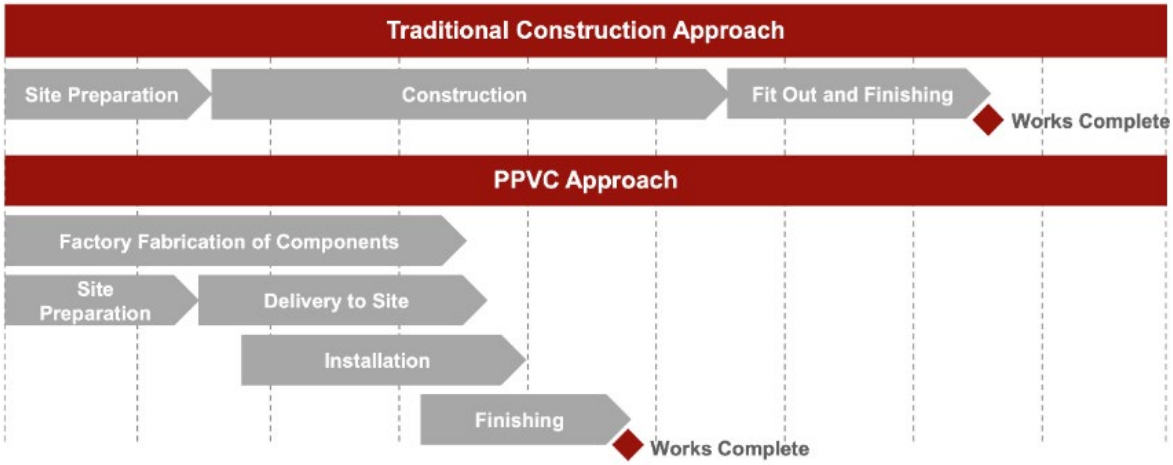


Figure 26: Comparing duration of the traditional process with the process of using the PPVC elements. [35]

Graphics below presents the suite prepared for the production in the PPVC method.

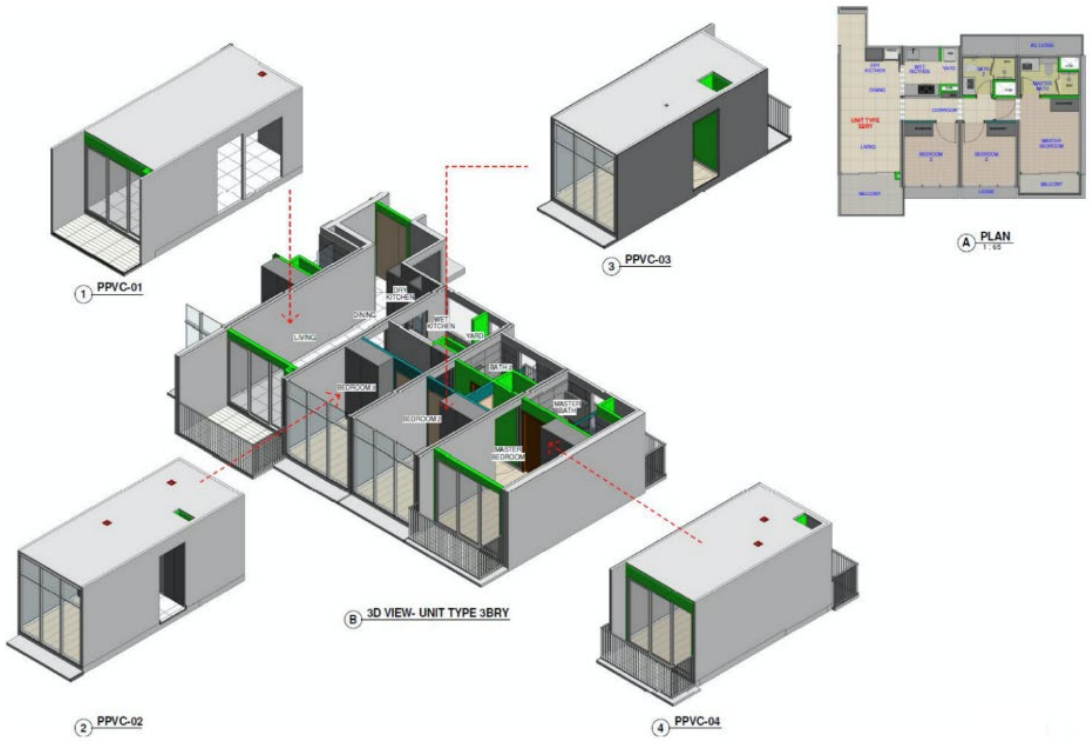


Figure 27: Example of digital model of modular, prefabricated and completed large-space parts of the suite for later assembly. [34]

Please find below the model of residential complex with parts marked in blue built from PPVC elements:

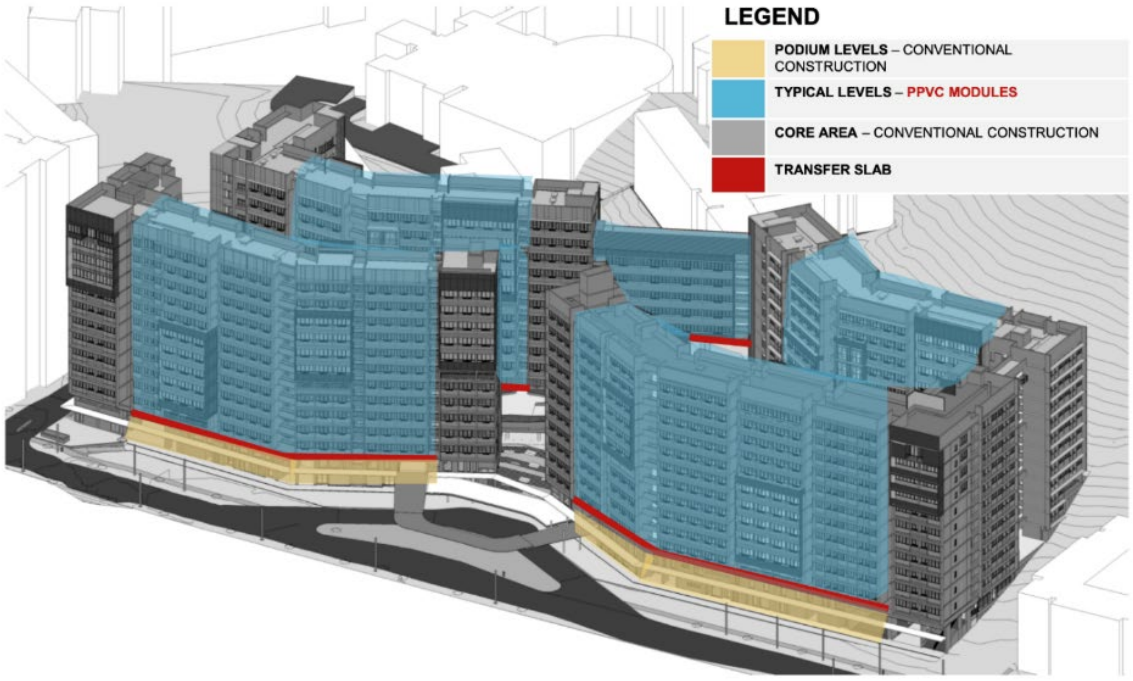


Figure 28: Model of the residential block with specification of parts prepared in situ and prefabricated as PPVC (marked in blue). [35]

This Roadmap recommends the fastest possible implementation of similar automation processes in the Polish construction sector for reducing waste and accelerating the stage of creating and delivery of the investment assets.

5.3.2.7 Trainings

Cyclical trainings will be most advanced trainings of all trainings for the BIM methodology due to the high integration of a human factor and human relations in realization of the project-execution phases. The involvement of practioners is suggested in the building investments with experience in integrated investments. Theoreticians are not in the case of the phase discussed the best training subject.

The first trainings of that type should be conducted as a few-day long workshop for familiarizing all stakeholders with the process of elements of the BIM methodology at the very beginning of the investment.

5.4 Operational phase

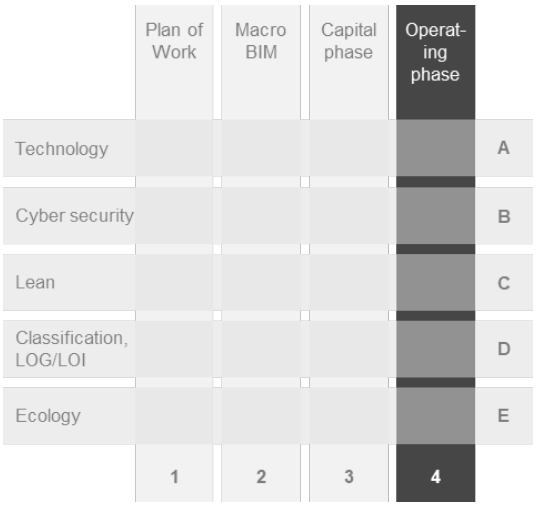


Figure 29: Operational phase – fourth element of the matrix for the temporary phases of the investment.

Own elaboration

5.4.1 Legal-normative system

- Standard **PN-EN ISO 19650-3** on managing the delivered assets (not published yet, under study). This is a future normative standard for the operational phase of the building or infrastructural investments with the use of the BIM methodology in Poland;
- Series of ISO 15686 standards (Building Construction – Service Life Planning) on life-cycle costing of assets, especially **ISO 15686-4:2014** (Part 4: Service Life Planning using Building Information Modelling) on using BIM for this purpose, with a note on COBie[99] as an alternative representation of table data for that purpose;
- Series of ISO 5500X standards on methods of asset managementof any type (Polish version is expected by the provisions from the standard text) published since 2014 was not prepared for the BIM methodology. It was established on the basis of the British PAS 55 from 2004. In parallel to ISO 55000:2014 another standard from the series was published– ISO 55001:2014 – containing requirements for the systems of asset management. Another standard from the 5500X (ISO 55002:2018) series contains the principles of using the 55001 standard and in 2019 the standard ISO/TS 55010:2019 was published with the next improvements of asset management for financial and non-financial factors. It is not certain yet, whether the series ISO 5500X will be included into the package of the „BIM" standards,

[99] COBie (Construction Operation Building information exchange) – open format of data exchange, prepared for asset management.

whether the methods for asset management in the construction system will be the topic of the next ISO 19650 series. The Technical Committee ISO TC251 does not give a binding answer[100];

- British standard BS 1192-4, which was to be transformed into the ISO 19650-4 standard contains a specification of the information format, allocated to manage the asset in the phase of its operation namely the operational phase, referred to in the chapter. This is a set of data called COBie (Construction Operations Building information exchange). Most probably however there will be no publication of ISO 19650-4 in such a form, as the format COBie is a sub-set of data of other format IFC, which in turn from already a dozen of years has been a world standard, thus repeated COBie standardization would not have justification;
- Standard ISO/ICE/IEEE 15288:2015 (Systems and software engineering – System life-cycle processes) within the procedural frames for describing the life cycle of human made systems, also as single products or services provided by them;
- Series of ISO 3700X standards, concerning Smart Cities.

5.4.2 Description

5.4.2.1 AIM – Asset Information Model

In parallel to the PIM model (although depending on the form and provisions of the contract), the asset model is transferred to the appointing party (AIM) for the maintenence-operational period. The model is cleaned from unnecessary information, collected in time of creating and delivery of the asset (delivery phase). It is dealt by the party which obtained such a task in the contract. Currently most technologically mature procedure for creating the operational model consists of four basic steps:

- **Elimination of the unnecessary information for asset management**. This is such information as data on managing the chain of supply during creating the asset, with logistic coordination, on schedules of the transfers of project data or on managing and later disassembly of elements of construction site organisation;
- **Completing the AIM model with data concerning Facility Management (asset management)**. They consist of the information concerning manuals of operation of the built-in and free-standing elements of equipment, dates of periodical reviews, lapse of guarantee dates, producer information or other significant data. The standards from the 19650 series define and recommend to create AIM already in the delivery phase as parallel to the PIM model of information (see point 5.3.2.1). In order to create AIM data of the project model is completed in the form of LOI text information, best separated from geometry data (see „decoupling" point 5.8.2.3.) The format of target record of such data is COBie (Construction Operations Building information exchange – see further on point 5.4.2.2);
- **Completing the model with interfaces and plugins to collect the readouts of information** from all in-built sensors, cameras and other data generators in the physical asset;
- **Creating a digital model called Digital Twin,** being the truthful copy of the physical asset and obtaining from „physical twin" by means of Internet connections remote information on its current status with reference to all built-in systems, installations and devices (see further on point 5.4.2.3).

5.4.2.2 COBie (Construction Operations Building information exchange)

COBie is one of the forms of passing sets of information on delivered asset for the period of its operation, called generally XXXie. Other XXXies include e.g. SPARKie (information on electrical systems), HVACie (on heating-ventilation-air-conditioning systems), BAMie (on systems of building automation), WSie (on water systems), LCie (on managing the life-cycle of the asset), QTie (data on survey quantities), etc.

[100] http://www.55000.org.cn/wp-content/uploads/2020/01/TC251_2020_January_2020_compress.pdf [Access: May 2020] [83]

The most important set of the afordementioned lists of the format for managing the usage of the asset is the COBie data. It constitutes the sub-set of the IFC format (called MVD – Model View Definition, namely the view of part of complete data of the model of digital information on the asset prepared for a specific purpose, in this case managing operation). Placing proper options of export of the project model to IFC will assure proper transferring the COBie information for further managing of the asset by the agendas of the appointing party.

Specialist computer applications (both commercial and free of charge) process the IFC models with COBie data to Excel files (or XML files imported to Excel). A feature characteristic of the COBie file, recorded in the XLS(X) format, is a specific colours of columns with different types of information. There are four of these colours (graphics below):

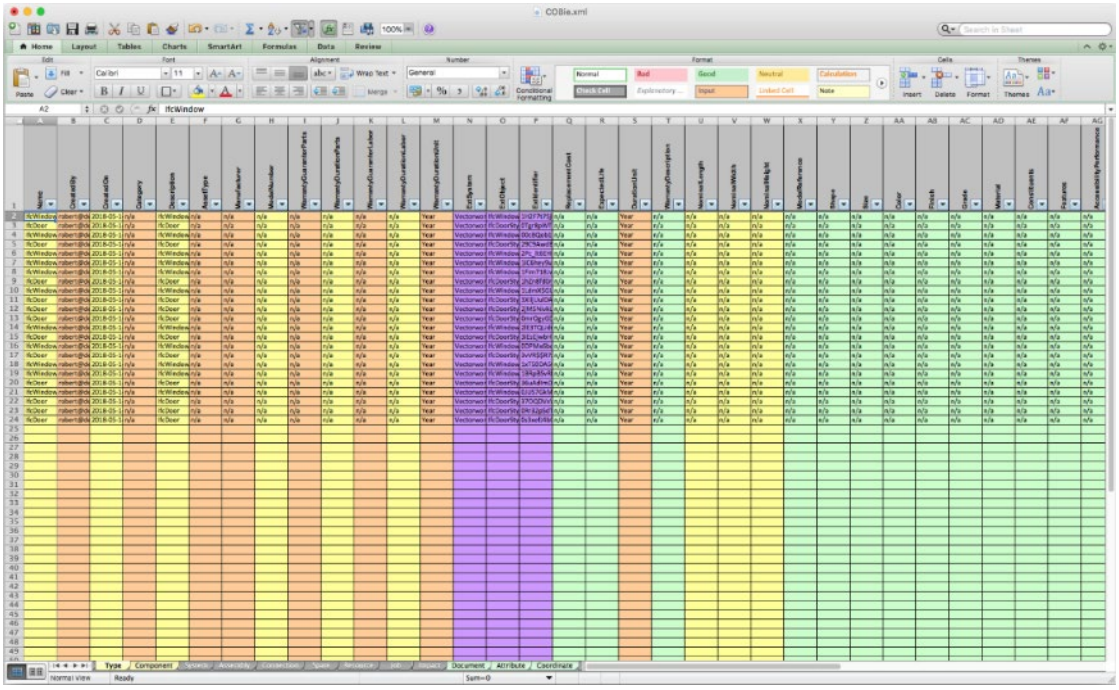


Figure 30: Appearance of the Excel file with tables COBie.

Own elaboration

Yellow and orange colour shall mean necessary data taken from the programs to create and manage BIM by means of automatics of identification keys of internal records of databases obtained as a result of system queries. This is data which was recorded by the designers and engineer consultants during the project process in the PIM model during creating the information for the AIM model. The information with the violet background is automatically generated by the computer program, the green fields mean optional fields.

COBie consists of 19 tables in the Excel format and their structure consists of three scopes (tables concenring project, execution and general data). The most important for the operation information are the tables type Type and Component. Data COBie completes the tables juxtaposing all information.

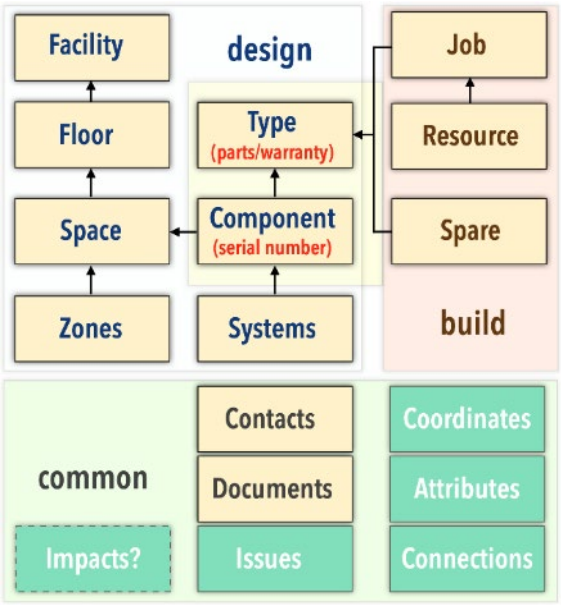


Figure 31: Structure of COBie information collected in 3 scopes and 19 tables[101]

As it was mentioned in the introduction to the chapter format COBie is not directly standardized and is not translated into other languages, descriptions of tables remain in English. Despite its usage in the Polish road to BIM is recommended in the Roadmap for the following reasons:

- It is a sub-set (namely it is completely contained in the information structures) of the IFC format which in turn is subject to ISO 16739-1:2018 normalization;
- May be obtained from each application with the export to IFC format;
- It is an open and non-commercial format;
- There is no other finished and commonly used format, adjusted to service operation data of the building or infrastructural asset created in the BIM methodology.

5.4.2.3 Digital Twins [102] [103]

This is a digital form of representation of the asset with the highest degree of technological development. Digital twin with physical twins allow both for managing asset from any place on the earth and processing information of any type, jointly with so called Big Data[104], stream of not structurized data flowing from the elements of the asset's equipment and for 24 hours.

The digital twin in combination with the distributed processing technology (Distributed Ledger Technology - chapter on cybersecurity) are an integral part of the Polish Roadmap for BIM in order to ensure the security of sensitive data flowing in both directions between a physical object and its digital counterpart. Examples of current Digital Twin applications are such highly technological environments as airports (Dutch Schiphol[105] or the American La Guardia[106]).

[101] Own elaboration on the basis of https://blog.areo.io/what-is-cobie/ [Access: May 2020] [84]
[102] https://www.controlengineering.pl/cyfrowy-blizniak-jeszcze-wizja-czy-juz-rzeczywistosc/ [Access: May 2020] [85]
[103] https://przemysl-40.pl/index.php/2017/12/04/cyfrowy-blizniak/ [Access: May 2020] [86]
[104] https://pl.wikipedia.org/wiki/Big_data [Access: May 2020]
[105] https://www.arcanagis.pl/cyfrowy-blizniak-pomaga-zoptymalizowac-operacje-lotniskowe/
[106] https://devpost.com/software/digital-twin-of-airport

The information may come from sensors of the equipment elements, receivers of electrical networks, in-built installation and environment systems, communication and transport infrastructure, CCTV systems and all other sources of information with the types listed in the standard 19650-1. Digital Twins in fact require constant flow of information. Managing this data is a complex process, the basis of which is the data information security (cybersecurity). For the service of the digital twins, also the Lean rules are applicable, meaning the reduction of waste and slim management.

Digital Twin reminds a digital, spatial project model, supplied with many interfaces to accept the streams of information from one's own environment and by means of network connections with the whole Internet of Things. This is at the same time an intelligent facility which additionally is subject to evolution of machine learning. There are four levels of development of digital twins:

- **Pre-Digital Twin**: digital system model with extended technology and possibility to manage technical risks but without physical equivalent and without a possibility to obtain data from physical environment nor machine learning on any level (operator or system-environment);
- **Digital Twin**: digital equivalent of the physical twin, obtaining the information from the physical equivalent which monitors its operational status, technical health and making its updating, but without the possibility of machine learning;
- **Adaptive Digital Twin**: digital equivalent of the physical twin, possessing adaptation interface, contrary to Digital Twin possessing a possibility of updating physical equivalent in real time and ability of machine learning on the level of operator;
- **Intelligent Digital Twin**: additionally, having an ability of machine learning on all levels.

The graphics below presents evolutionary process of maturing relations between twins:

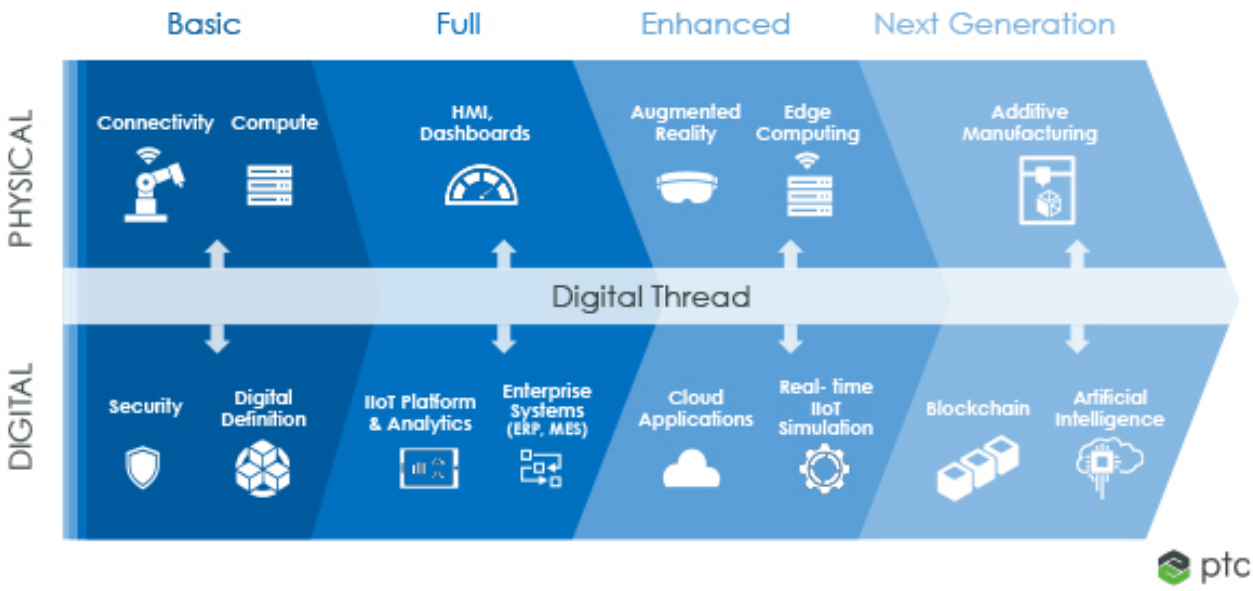


Figure 32: Evolution phases of a digital twin.[107]

Digital Twins is subject to constant development, at the same time entailing the evolution of quality of physical assets and their mutual relations. The process systematically will manage the newly established technologies, and in strategic aspects it matches the idea of Smart Cities, where in digitalized municipal quarters intelligent facilities remain in different types and on different levels of mutual technological relations.

[107] https://www.7wdata.be/internet-of-things/the-evolution-of-digital-twin-and-how-emerging-tech-is-driving-adoption/ [Access: May 2020] [62]

In the meantime, the suggestions were created for the change of the twin name for „Digital Twinning", to emphasise its dynamic nature and constantly changing status[108] (Aidan Mercer, bSI).

5.4.2.4 Costs of life cycle of the asset (Life-Cycle Assessment)

Estimating the costs if Life Cycle of assets should be effective and conducted from the very beginning of the investment, namely from the phase of MacroBIM. Maintenence costs in connection with the personal costs of the operational phase of the facility constitute an overwhelming majority of investment outlays. During the creation process and delivery of the asset one may only calculate operational costs of the asset itself.

Personal costs will be included in the operational-business strategy of the appointing party.

The graphics below juxtaposes economic effects of the whole life cycle of the asset (30-40 years) in the building investments subsequently for the scopes (accepting for 100% costs of operation and managing human resources in this period of time):

- Project (2%);
- Construction realization (20%);
- Maintenence and management (100%);
- Operational costs (4000%);
- Assumed business profits (5000% +).

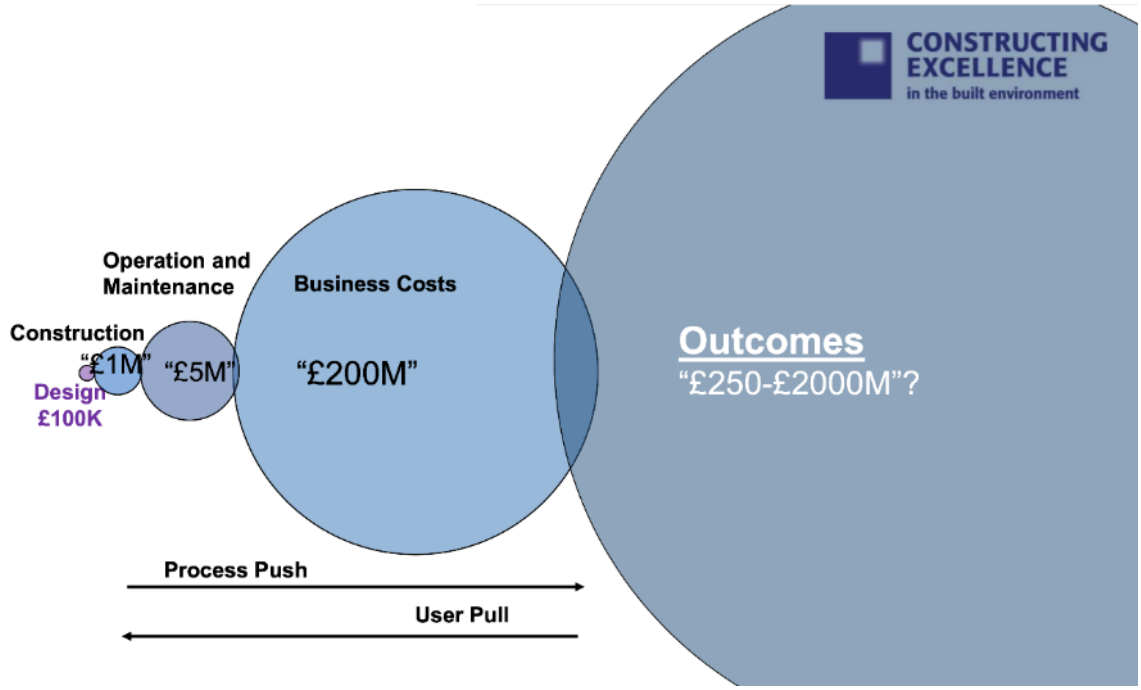


Figure 33: List of costs of life cycle of the asset. [36]

A key activity for the stage of creating and delivery of the asset is therefore assuring its profitability in the operational phase, because the delivery phase has influence on it. All activities connected with monitoring the Target Cost during creating and delivery of the asset contain also decisions on which economically the phase of asset management will depend. Target Value Design with its decisions, based on the largest benefit (CbA) is the best tool for this purpose provided the future operation outlays of the asset will be in the composition of the activities analysed. Saving with the cost reduction of TVD functionality will entail creating many unknown values for the future, affecting also its operational costs.

[108] https://blog.buildingsmart.org/blog/are-we-digital-twinning-yet [Access: May 2020] [87]

Using technologically advanced Digital Twins with the aid of slim management, based on the Lean principles is an extension of the Target Value Design methods on the operational phase of assets and more common and common direction in the world for the future of assets in the construction sector.

All investment phases for the business model ordering for the whole life cycle of the assets may be recorded in the form of consistent sequence with the stages of CDE by the graphics from the PN-EN ISO 19650-1:2019 standard. It is an open issue whether the CDE environment will be used by the appointing party in the maintenence-operational phase whether it finishes its functionality with delivery of finished assets by the ISO standards 19650-1/2.

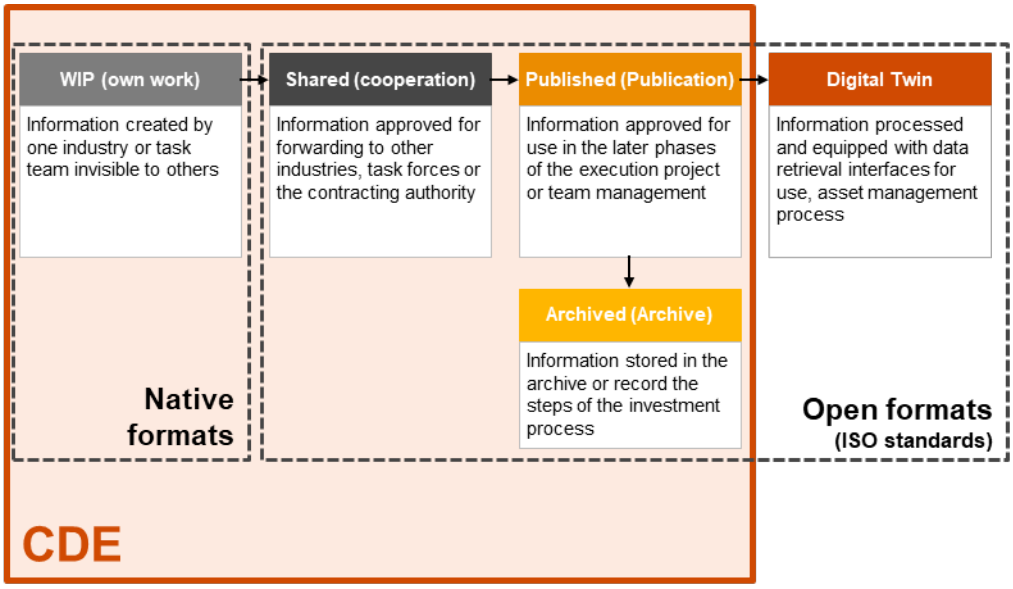


Figure 34: List of digital environments of the delivery phase with extension to the operational phase.[109]

As the base for the direction the specification was accepted for the level 3 BIM for open formats of information exchange (IFC-IFD-IDM) from the fragment of the „wedge" Bew-Richards, in accordance with which the target condition is a common work in open, editable formats in one "cloud" environment or another future form. Also, the evolution of the IFC format goes towards the direction, **AND THE BASIS IS THE SECURITY OF THE INFORMATION SAVED FOR THE WHOLE LIFE CYCLE OF THE ASSET BY MEANS OF STANDARDISATION OF ITS PHYSICAL FORM BY ISO STANDARD.**

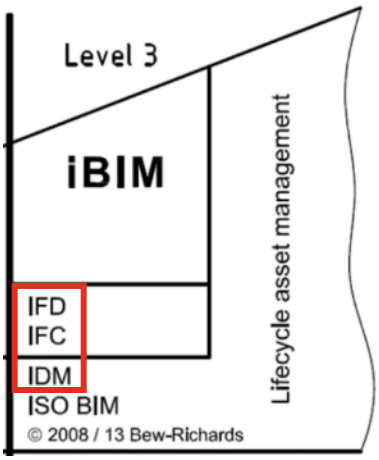


Figure 35: Fragment of graphics of Bew-Richards wedge, imaging the highest level of BIM development. [37]

[109] Own elaboration on the basis of the standard PN-EN ISO 19650-1:2019

5.4.2.5 Digital Built Poland

Polish strategic document for the activities by 2030 was developed by the Ministry of Administration and Digitalization and accepted with a resolution of the Council of Ministers in February 2013. The document called „ Long-term Development Strategy of the Country. Poland 2030. Third Wave of Modernity"[110] in chapter 4, Goal 5 describes the directions for creating the Digital Poland. The document recommends in the long-term perspective the activities for building digital community:

- supporting investment in broad-band infrastructure in order to assure common access to the Internet of high quality;
- building the digital competences and implementing the common digital education;
- assuring supply of high-quality content available in the network;
- creating comfortable legal conditions for the market development of electronic services;
- collecting, storing, securing and making the data of traditional resources available in electronic form.

The document constitutes the base for the concept of digitalization of the whole are of Poland, as for example it was accepted by a strategic document Digital Built Britain [2]. In the continuation of the strategy in the next years it is recommended. To indicate a coherent system, able to be managed digitally by the authorised entities, taking into account other possible areas for the needs of the Digital Poland and further realization guidelines.

Another strategic document „Strategy for responsible development by 2020 (with a perspective by 2030)" [38] was adopted with a resolution of the Council of Ministers in February 2017, The study was a continuation of the "Plan for the responsible development" accepted in February 2016 by the Council of Ministers, the strategic guidelines of which of twelve inter-resort teams were accepted in July 2016 by the Coordination Committee for Polish Development.

The document contains, inter alia, strategy of digitalization, which is based on guidelines of the previous study but was completed with a few significant points from the point of view of implementin the BIM methodology of aspects (graphics come from the document discussed):

- Cybersecurity within construction of the information community;
- Energetics (Smart Grid)

Power engineering (Smartgrid)	
In 2015, the demand for energy amounted to 13.5 billion tons of oil equivalent (in 2000 it was 10 billion tons) Over 81% of energy was produced from coal, oil and gas	
The use of Smart Grid technology - improving energy flow between energy producers and consumers	Examples of use: • Power quality measurement • Reading customer meters • Switching energy tariff • Controlling devices at home • Detecting fraud

Figure 36: Part of strategy concerning energetics. [38]

[110] http://kigeit.org.pl/FTP/PRCIP/Literatura/002_Strategia_DSRK_PL2030_RM.pdf [Access: May 2020] [63]

- Transport and logistics

Transport and Logistics (Inteligent Transport Systems)	
Intelligent logistics centers that, thanks to the use of information technology, allow access to information in real time, enable analysis and processing of information remembered by participants in the supply chain, for example UPS RFID network	Examples of applications: • Increasing street network capacity on average by 22.5% • Improving road safety (reducing the number of accidents by an average of 60%) • Reduction of travel time and energy consumption (by nearly 60%) • Reduction of combustion emission by 40% on average • Improved travel comfort and traffic conditions • Reduction of rolling stock management costs • Reduction of costs associated with the maintenance and renovation of the surface • Increasing economic benefits in the region

Figure 37: Part of strategy concerning transport and logistics. [38]

- Intelligent cities, buildings and vehicles

Intelligent cities, buildings and vehicles	
Smart cities combine the smart use of modern technologies and innovative systems with the potential institutions and scientific centers functioning in companies	
Smart buildings enabling remote control of ventilation temperature with building lighting, home appliances and monitor the safety and consumption of utilities	Examples of use: • Monitoring of air pollution • Implementation of the idea of smart buildings • Implementation of smart vehicles • Support for disabled people • Generating alerts against natural disasters

Figure 38: Part of strategy concerning intelligent cities, buildings and vehicle. [38]

The study does not include still any digitalization guidelines which are significant for the complete image of the multi-dimensional digital Poland, as well as elements of geospace, ground infrastructure and underground one or natural water reservoirs.

The European Union gave the funds for strategic studies for the years 2021-2027[111]. Due to the fact that Polish general strategy (2014-2020) finishes in fact the scope of its effectiveness, and long-term one (2030) defines in a general manner the direction of digitalization it is recommended to apply for subsidy for the continuation of the project already with proposal of specific activities in all above scopes. In order to prepare the market for the complex activities in the building sector it is recommended to develop strategic document, limited to the task of conducting digitalization of the whole Poland. In this way the activities could be focused and directed for better effectiveness. The step in a good direction is the supported Program of Integrated Informatization of the State accepted in 2014 and updated every few years.

[111] https://www.funduszeeuropejskie.gov.pl/strony/o-funduszach/fundusze-europejskie-2021-2027/ [Access: May 2020]

As a target the form of digitalized parts of Poland in this way it is recommended to use the intelligent functionality and machine learning, which are possessed by the advanced evolution level of Digital Twins, placed in the network.

As an example:: British CDDB (Centre for Digital Built Britain) from the University of Cambridge developed a strategy of using Digital Twins called „The Gemini Principles" [39] with a recommendation of a digital twin for the whole Great Britain consisting of smaller Twins.

5.4.2.6 Trainings

The sector most involved in the operational phase of investment is broadly understood as Facility Management (asset management) and to these specialists all trainings in this respect should be directed. These trainings should also cover the Lean elements, especially the principles of slim management and reduction of waste („muda"), as well as principles of Lean Six Sigma[112] in operational processes. The supplementation of these trainings in the future will be the tutorials of operation of rich functionalities of Digital Twins.

Also, the sector preparation is recommended of the specialists by their own professional organizations so that they could conduct professional trainings in the area of intelligent assets. The alternative will be the asset management by the external entities which will use this opening long-term segment of the market.

5.5 Technology

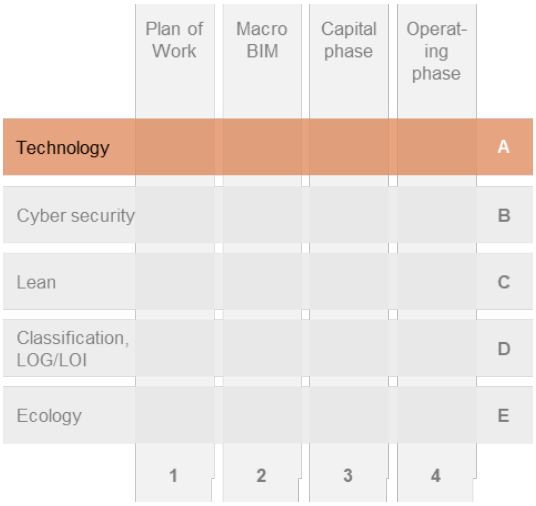


Figure 39: Technology – the first element of the matrix from contents.

Own elaboration

5.5.1 Legal-normative system

- The current direction of BIM standardization for Poland is a cycle of standards called **PN-EN ISO 19650**. This is a series of publications, containing structurised (first in Great Britain) and then standardised world standard of proceeding the investment in the integrated BIM methodology;
- From the computer software with the normative standard **ISO 16739-1:2018** is open format of information exchange called IFC (Industry Foundation Classes)[113] and related BCF (BIM Collaboration Format) and CityGML, constituting the implementation of GML (Geography Markup Language – ISO TC211 and OGC) for the service of geo-spatial information. The world strategies of BIM implementation (UK, Czech Republic, Finland, Norway, Denmark, Sweden, etc.) are based on IFC as a basic format of information exchange. Within integration of CityGML with BIM (before a common format of information

[112] Connection of Lean principles with the Six Sigma model, see point 5.7
[113] Open format of information exchange in models. Full deifnition in the dictionary see also point 5.5.2.5

for BIM is created and geospace in the next version of IFC 5) the BIM insert was developed for CityGML called „GeoBIM" [40];

- Series of standards ISO/IEC 21823–(Internet of Things (IoT) - Interoperability for internet of things systems) concerning Internet of Things: **ISO/IEC 21823-1:2019** (Part 1: Framework), ISO/IEC 21823-2 (Part 2: Transport interoperability) – under study; standard **ISO/IEC 30141:2018** (Internet of Things (IoT) – Reference Architecture).

5.5.2 Description

A technological factor possesses the richest literature from all elements, occurring in the whole project. It consists both of strategic studies or recommendations as well as already developed standards, in force in individual countries, and their communities, for example European Union. It also covers all documents which had already been developed in Poland for the normative or standardizing purposes are created currently or will appear in the forthcoming future.

A basic element of technology, irrespective of whether analogue or digital, is the information. Its current and predictable forms are listed and analysed in the points below.

5.5.2.1 Structurisation of information

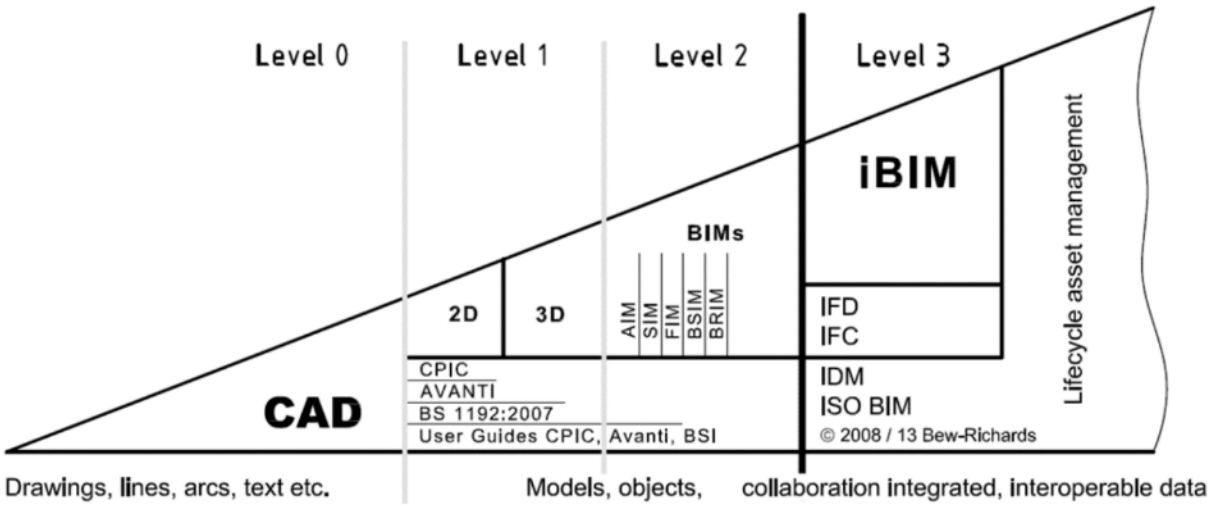


Figure 40: Bew-Richards Wedge, main element of the strategy of BIM implementing in the UK.[114]

As it results from the above graphics of the British „wedge", BIM goes towards the management in project processes, building and operational ones, treated as a whole. One should understand through that not the work on files, CAD drawings or even BIM models, but the management of the information base on a given investment for the whole duration thereof namely the process connected with data, the information (Eng. data-driven). There are a few types of methods of collecting and storing information:

- Not structurised, namely chaotic– data as it goes in, is put aside at its recipient in any manner, without specific storing structure. Selecting a necessary information from the set is a very challenging task;
- Partially structurised, **objective** – for recording data there are protocols on object programming (JSON, XML, Python and other higher languages of object programming, such as for example. Java). The data is collected here in the types of facilities and their instances (created for that purpose copies of these facilities). The required information is obtained by means of the programming interfaces so called API (Application Programming Interface);

[114] https://shop.bsigroup.com/upload/Construction_downloads/B555_Roadmap_JUNE_2013.pdf [Access: May 2020] [37]

- Structurised – higher level of data storing, e.g. with the aid of simple relations or diagrams enriched with sematic questions (as Triplestore) or other multi-model (as graphs with their relations, knots, attributes and labels) generally called **relational databases.** The information is called by them by means of system queries, as for example SQL (Structured Query Language)[115];
- Personalised – complex method of storing information from dedicated and controlled sets of data of specific purpose (e.g. **Digital Twins** – see point 5.4.2.3). Presently we deal with constantly increasing stream of information generated in the world, accumulating in the inflowing readout in each second in real time, of so-called Big Data. The information is here monitored live and obtained from digital facility, being a truthful virtual copy of the real equivalent. The example of using personalized method of data storing may be digital twins of electric cars by Tesla[116], created individually for each manufactured vehicle and used for remote monitoring and any modification of its current condition at any time of operation.

5.5.2.2 Evaluation of the existing information

On one hand, the seeking to structuring the information is observed but on the other hand there is a current stream of information in everyday life and economic which belongs to all four types listed in point 5.5.2.1 and one should assume that such a state of affairs will keep on for some time.

The ISO standard for BIM 19650-1:2019 in point **4 Asset and project information, perspectives and collaborative working**, sub-point **4.1 Principles** emphasises the existence in models PIM (project model in delivery phase) and AIM (asset model for the operational phase) information also not structurised (e.g. documents, video or audio recordings). The current technological status forces to manage the information of any type, also raw one, as for example, listed further on in the Standard of soil samples and the products in not structurised form.

The future however belongs to the standards of information of all type. This is preventive suggestion of the norm, taking into account however still the analogue data, but which should be subject to changes in accordance with the diagram presented in the Standard of progressive maturity of information management for the level 3.

In searching for an effective and flexible system of data evaluation of each type, and especially the information from the sensors in real time, data for the machine learning, analysis of information from relations data bases or service of artificial intelligence and virtual and extended reality (AI / VR / AR), different concepts appear in the world. The most promising seems to be at that time the so-called Lakehouse model[117] – graphics below– constituting a logical evolution for information managing.

The first step was so called Data Warehouse, namely the reporting system and data analysis, being the basis for the business intelligence. However, it was not optimized for the service of not structurised data, as audio files type, video images or text, characteristic for e.g. development of artificial intelligence. (AI).

To complete the gap, the combination of many Data Warehouses was used with the model of newly created concept at that time of Data Lake (– system of data repository in natural formats such as blobs or files of any format) and systems for the service of streaming, graphs or data bases for images. The result was not optimum, as it caused the slowdown of the information flow.

The Lakehouse concept emerged from the data lake as an antidotum to the existing shortages and constitutes a synthesis of the above systems for the complex service of the information of each type.

[115] https://pl.wikipedia.org/wiki/SQL [Access: May 2020]
[116] https://blogs.dxc.technology/2016/09/08/the-digital-twin/ [Access: May 2020] [89]
[117] https://databricks.com/blog/2020/01/30/what-is-a-data-lakehouse.html [Access: May 2020] [90]

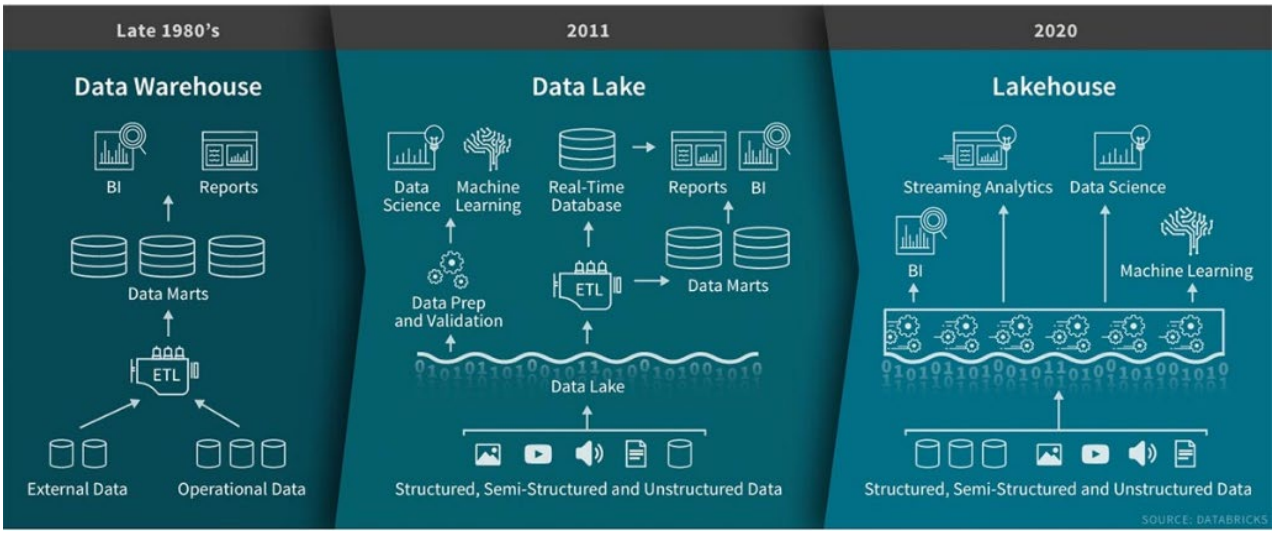


Figure 41: Evolution of the formats of digital information and methods to manage them.[118]

5.5.2.3 Standardised information

The standardization of information already structurised involves its regulation. A general principle is to create a standard for any economic area is first maximum possibly structurisation of resources / data/ format / form of information and after the period of satisfactory functioning of structures on the market there is development of the structurising document. The regulatory authorities deal with this in each country. In Poland this is Polish Normalization Committee (PKN) with its execution structures (Technical Committees) and in the world International Organization for Standardization (ISO), is responsible for majority of standards in the form of ISO standards (about 17'000).

Regulated information for the BIM methodology was published in the form of series of PN-EN ISO 19650 standards described in point 5.3.1 and 5.4.1.

In the chapter devoted to Lean of the document (point 5.7) the organisation methods were indicated of the execution entity in construction sector, being the equivalent of normative requirements but from the „bottom-up" side („push"). These methods visualize and synchronise the activities in accordance with the principles of the Convergence, common platform for managing the information being created about the investment.

5.5.2.4 Big Data

By the diagram of 2015 from the portal upriser.com, associating to the rule Gordon Moore[119] the amount of information in the world will double every two years in the next decade[120], and for the next years not straight-line arithmetical but geometrical increase is estimated. The management of this stream of data growing year by year requires already not individual activities but a complex approach.

In the set of tools for the service of the stream, flowing constantly and with larger and larger intensity there are many existing and developing technologies:

- IoT (Internet of Things) – a new definition of Internet network, based on higher capacity of data and new technologies for its processing. Its mass and integrated involvement in economy is assumed;
- Cloud Computing – existing solutions for central, not local and remote data processing;

[118] https://databricks.com/blog/2020/01/30/what-is-a-data-lakehouse.html [Access: May 2020] [90]
[119] https://pl.wikipedia.org/wiki/Prawo_Moore'a [Access: May 2020]
[120] http://upriser.com/posts/data-is-expected-to-double-every-two-years-for-the-next-decade [Access: May 2020] [91]

- Edge Computing (architecture of dispersed IT resources), hereinafter referred to as Fog Computing (calculation fog) – evolution of information processing, combining remote and local processing with the aid of using intelligent filtrating gateways;
- Distributed Ledger Technology (Dispersed processing) (See point 5.6.2.3) – distribution of processes of information processing to many network devices, using their calculation powers and increasing the data safety by means of dispersing their control centers;
- Network 5G – new technology of wireless networks with increased frequency and intensity, favourite to service of larger stream of information. Its functionality is guaranteed by a new network of satellites. This is also a source of many controversies concerning its presumed influence on health. In Poland there are currently research and tests conducted and the first attempts to apply.

Big Data is one of the types of information, used in the investment processes in construction sector, which are listed in the PN-EN ISO 19650-1:2019 standard. In a strategic document as the one, therefore it is presumed therefore to prepare the tools for the service and the type of information with the aid of the above-mentioned technologies. In the element of matrix concerning cybersecurity the tool of distributed processing (DLT) called Blockchain is elaborated on broader (5.6).

5.5.2.5 Application of open standards and formats

The information in integrated processes uses also the computer programs to generate it and analyse. There are two types of formats of computer files. The first of them is so called normative formats, specific for vendors of the software, generally technically reserved and rarely compatible with native formats of other producers. The second type of the format of information is the so-called open format, available for each user, also in the form of source code.

For the BIM methodology in mid of the 90s of the previous century, in cooperation of many companies the IFC format was developed (Industry Foundation Classes), based on former format STEP. Both are based on ISO standard (respectively 16739 and 10303) and due to this constitutes safe form of generating and information exchange. Derivative, because also open formats of data service, i.e. BCF (BIM Collaboration Format)[121] for the correction processes of the BIM models in the form of questions and answers for the existing unclear issues or errors in the project-enforcement phase.

The advantage of the open formats is their light nature, resulting in small sizes of model files, carrying the information on the created asset. The IFC system, developed and certified for the computer applications by the not-for-profit buildingSMART International organisation, constitutes the guarantee of fulfilling another requirement of the integrated processes: so-called “interoperability”. An English term „interoperability” means a lossless cooperation in information exchange between any computer software, certified for import and/or export of IFC files.

At the end of April 2020 buildingSMART International announced in their Roadmap [41] the creation of a new data format with the name of IDS (Information Delivery Specification). This format is supposed to define the information requirements and the method of this exchange in the form of machine-readable data chunks from the information model.

5.5.2.6 CDE (Common Data Environment)

The principles for creating digital environment of the investment are recorded in first both parts of the standard PN-EN ISO 19650. The function of assuring CDE is ascribed to the appointing party, but the standard allows to fulfill the funtion both to the contractor (lead appointed party) and the separate entity. In such a case the entity must become a part of the Integrated Team with all ots rights and obligations.

CDE is a digital environment for conducting the investment in its phase of creating and delivery of the asset. It is not required yet on the stage of MacroBIM, but, as the main entity, responsible for delivery of CDE is the

[121] BCF format us used for information exchange in model files viewed. One may record in it notes and attach „photos” of models with adding reference of pages, which are responsible for referring to the notes.

appointing party (although it is possible also to provide and service of CDE by the contractor (lead appointed party) and even third entities) the earlier it appears in the investment process the better. The CDE system is available based on roles of access and contains in it minimum at least functions of information repository on the project and a possibility of electronic orders (and others), depending on the model and the price usually month or annual rental for the persons or groups.

The CDE topic is broadly described in another part of the project („Managing the building investment in BIM methodology – draft document templates").

5.5.2.7 Technological support, workshops

Another function, but present and valid for all elements of the strategic matrix is constant support in the form of adequate trainings and courses. BIM has a Chance to be fully implemented when the participants of building processes of all levels will accept technological, normative and social principles of integrated processes. For this purpose, it is recommended to conduct cyclical trainings, also during the project delivery phase in BIM methodology.

In Poland there are many entities, training participants of the integrated processes, specializing in the openBIM methods (i.e. based on IFC, BCF or COBie formats standardized by ISO).

5.6 Cybersecurity

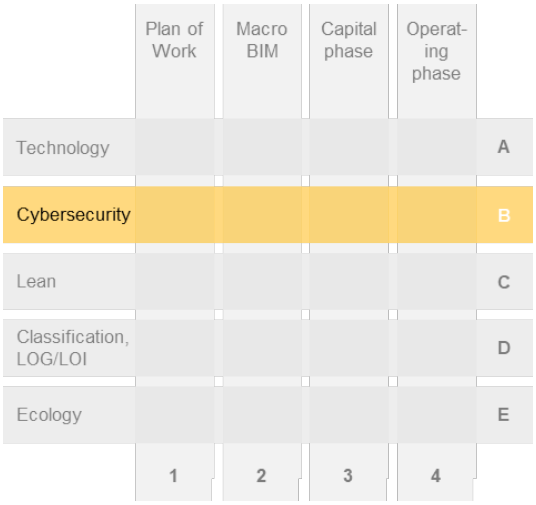


Figure 42: Cybersecurity - second element of the matrix in terms of its substance.

Own elaboration

5.6.1 Legal and regulatory ecosystem

- Regulation **(EU) 2016/679 of the** European Parliament and of the Council of 27 April 2016 on the protection of individuals with regard to the processing of personal data and on the free movement of such data and repealing Directive 95/46/EC (General Data Protection Regulation);
- Act of 10 May 2018 on personal data protection (**Journal of Laws 2019, item 1781**)[122];
- Act of 5 July 2018 on the national cybersecurity system (**Journal of Laws 2018, item 1560**) [42]. The proposals for the amendment concern the introduction of a more secure distributed ledger technology (DLT) than the traditional single server system, already used by global but also Polish public entities;

[122] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20190001781/O/D20191781.pdf [Access: May 2020] [92]

- Act of 4 February 1994 on Copyright and Related Rights (**Journal of Laws 2019 No. 24 item 1231**)[123];
- Standard **PN-EN ISO 19650-5** on security of information management: "Security-minded approach to information management" (publication as the Polish standard announced by PKN). In a letter to the presidents and secretaries of national ISO organizations of 6 November 2017, ISO Secretary General Sergio Mujica presented the action plan of technology committees for IEC, ITU and ISO standards, including, among others, research on the introduction of DLT (Distributed Ledger Technology) to standards related to data security and identification management[124];
- ISO/IEC 2700X (Information security management systems) standard series on information security (approx. 50 documents);
- PwC Report of 2018. "**Cyber-roulette in Polish. Why do companies count on luck in the fight against cybercriminals**" [43]. This report is a real look at the application of digital security principles applied by Polish business entities.

5.6.2 Description

Cybersecurity is closely linked to digital technology. It is a factor that should be clarified for any action towards the evolution of integration in construction processes. It is not so much the elements and software packages that support BIM processes, but their technological foundation, especially the directions of its development (ICT - Information and Communication Technologies).

It is generally known that computer programs for creation, analysis and management in the technological sphere of BIM methodology are not yet ideal. However, they are constantly developing, using the latest technologies appearing on the market. Similarly, the strategic activities of BIM implementation on the Polish market in the form of a Roadmap should leave opportunities for technological development, supporting integrated processes.

5.6.2.1 GDPR (General Data Protection Regulation)

The nature of the data provided in BIM - including personal data (including authors of design studies, identification of persons using CDE platforms, etc.) is necessary to comply with the generally applicable legal regulations, including the GDPR Regulation.

5.6.2.2 Copyrights

Provisions of the Act on Copyright and Related Rights of 4 February 1994. (see Section 5.6.1) define very broadly the subject matter to be protected under the aforementioned Act. Pursuant to Article 1, section 1 of the Act, the subject matter of the copyright is any manifestation of creative activity of an individual character, established in any form, regardless of the value, purpose and manner of expression, i.e. a work. Article 1, section 2 of the aforementioned Act specifies the works subject to protection, which include, among others, works expressed by graphic signs, or architectural, architectural and urban planning works. What is important is that the catalogue of works constituting the subject of copyright, specified in Article 1(2) of the aforementioned Act, includes, among others, works expressed by graphic signs or architectural, architectural-urban and urban planning works. Importantly, the catalogue of works subject to copyright referred to in Article 1(2) is exemplary and open-ended, which means that a protected work may, in principle, be any manifestation of creative activity. Similarly, dependent works, including works by others and collections such as databases, will also be protected. In the context of BIM, the definition of "collection" as a database that meets the characteristics of a work may be particularly relevant.

As a rule, the issues related to the use of BIM and development of digital project documentation in the context of copyright protection will be analogous to the classic preparation of a project in an analogue (paper) form. Thus, the parties to the investment process will have to ensure, among other things, the transfer of author's

[123] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20190001231/U/D20191231Lj.pdf [Access: May 2020] [22]
[124] https://share.ansi.org/ISOT/Updated%20ISO-IEC-ITU%20coordination/2017%20ISO-IEC-ITU%20New%20work%20items/2017-11-06%20-%20ISO-IEC-ITU%20New%20work%20items.pdf [Access: May 2020] [64]

economic rights to particular parts of the work or to grant a license to use the work in particular fields of operation as well as to authorise the parties to a contract to exercise their personal rights.

Due to similarities and analogies between the design documentation prepared in the BIM model and classical documentation, the current regulations on copyright and industrial property rights do not stand in the way of applying BIM in Poland. The correct determination of rights and obligations of the parties related to transfer of copyrights or granting of licenses will be of contractual nature and should be reflected in the provisions of a contract.

Copyright is one of the oldest in the package of legislative forms related to the implementation of BIM, but not necessarily properly applied in construction investment contracts. The most important are two aspects of these rights:

- Personal rights of the authors are not transferable and belong to the authors as natural persons. These rights extend up to 70 years after the death of an author and may be exercised by their heirs as set forth in the Act. Any other interpretations are inconsistent with the text of the Act, and Article 58. par. Article 58(1) of the Civil Code declares a legal act contrary to the Act null and void;
- Property rights are subject to any contract, but it should be specified for what period they are to apply. It cannot be a perpetual use of created works by other entities.

As far as rights to works in BIM processes are concerned (mainly projects and especially files with an industry solution model), the current IFC2x3 certified IFC format is uneditable (MVD CV 2.0 - Model View Definition - Coordination View 2.0)[125] and provides all copyrights to an author.

When IFC4 certification is as common as it is now for IFC2x3 and the format is established as a new standard, a strict distinction must be made:

- IFC4 MVD **DTV** (Editable Design Transfer View) as a working format for the exchange of information between industries (for Shared Stageup work, i.e. direct, working exchange between certain industries to create their own industry models);
- IFC4 MVD **RV** (non-editable Reference View) as the format required to deliver the asset (for the Published stage of work, i.e. work completed and submitted to the common CDE repository, accessible to all participants in the process by access role).

Native formats, due to their editability, do not guarantee any copyright protection.

5.6.2.3 DLT (Distributed LedgerTechnology)

The most recent (although already existing since 2008) significant global achievement in this field is a Distributed Ledger Technology called Blockchain[126]. It is based on the concept of decentralisation of the Internet as it is known today, i.e. based on a certain number of physical servers that process and pass on the information received.

Blockchain assumes transfer of all information processing power to electronic devices located in the network, not necessarily even computers or smartphones, but devices with significant processor power. All transactions are broken down into blocks and parcelled out on devices in the network - hence the Blockchain. In order to be able to modify an already existing transaction for any purpose, be it financial or any other, all the blocks scattered in the network would have to be modified, which seems virtually impossible. Each modification adds a new time code with a new identifier to the block and the block is removed from the block chain for that transaction, as it becomes a different, alien creation. All transactions are visible on the network for all users who are online, but only as global time code identifiers, without providing any details of these operations.

[125]MVD - Model View Definition is a selected part of the whole information model, with preparation for specific functional purposes (e.g. for cost calculations, for energy analyses, for asset management, etc.). Such exports are prepared by application manufacturers to create and export geometric-text information models.
[126]https://pl.wikipedia.org/wiki/Blockchain [Access: May 2020]

The following financial illustration of the Santander Group shows the difference in the processes of financial transactions in a centralised and distributed system (Distributed Ledger)[127].

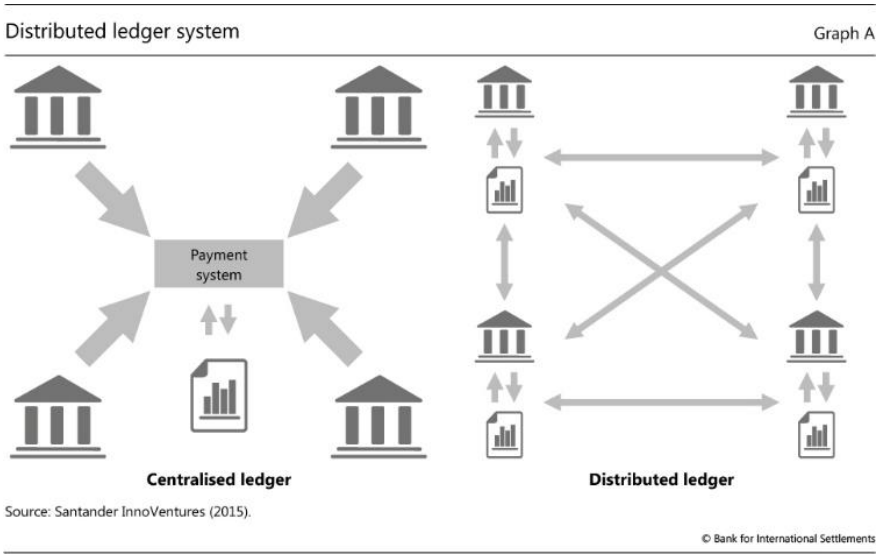


Figure 43: Difference between traditional, centralized ledger and using of a distributed ledger system.[128]

A more visual representation of the details of the Distributed Ledger System is shown in the illustration below. The third (right at the top) and fourth (left at the bottom) parts of the process illustrate the publication of the block and its subsequent verification (acceptance) in the network. In this way, another link is added to the chain of blocks with closely related transaction identification codes (the new transaction receives a code reference of the previous link from the block).

[127] https://www.bis.org/publ/qtrpdf/r_qt1709y.htm [Access: May 2020] [93]
[128] https://www.bis.org/publ/qtrpdf/r_qt1709y.htm [Access: May 2020] [93]

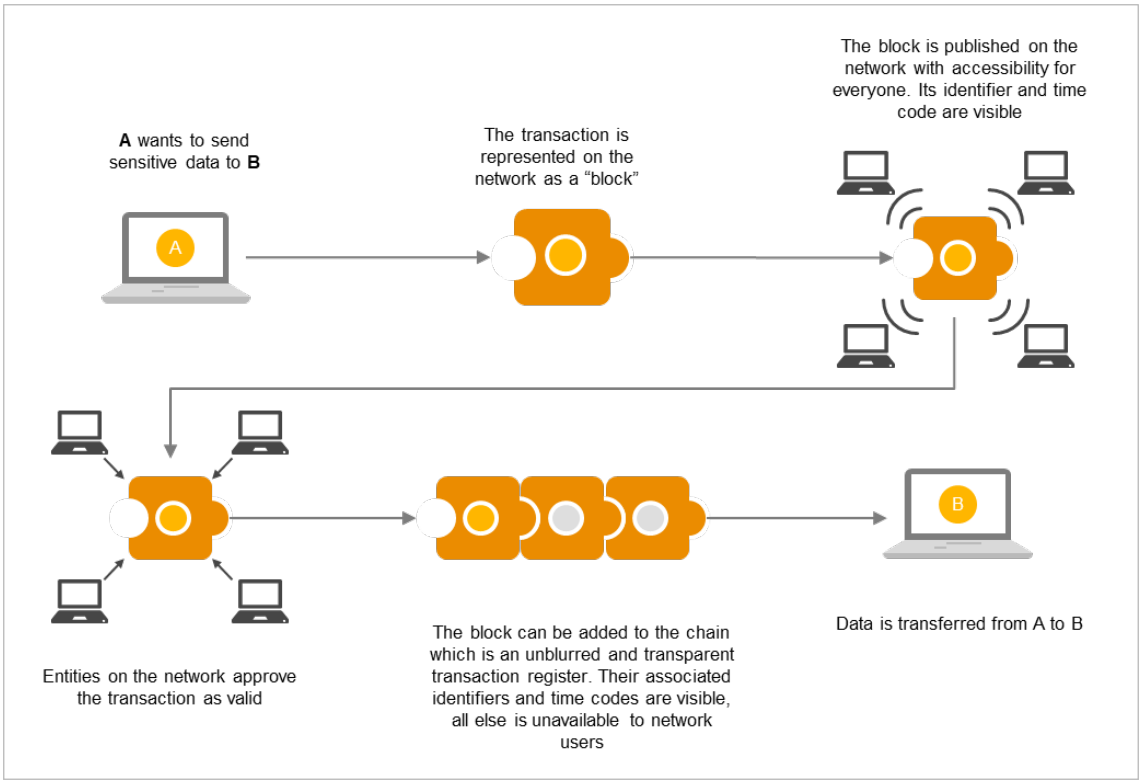


Figure 44: Operation diagram for entering an information block into the Distributed Ledger.

Own elaboration

The degree of security of Blockchain-based applications also responds in this way much better than traditional Internet security to the current requirements of the GDPR and the data protection issues relevant to construction processes, accumulated in long design, construction and operation processes, particularly sensitive in public contracts financed by taxpayers. It is especially important for Big Data information flowing in a continuous stream and in both directions from a digital twin to a physical counterpart, in technological facilities of national strategic importance (airports, energy networks). Therefore, the recommendation to use DLT has become a component of the Roadmap for Poland.

The advantages of this more secure data processing are appreciated one by one not only by users "digging out" new cryptocurrency facilities in the process of making the power available to processors, but also by local and state governments. Below are examples of applications of distributed ledger technology in public administration[129]:

- combating corruption (Singapore);
- citizen payments (UK);
- records (UK, Dubai, U.S.A. Delaware and Vermont);
- contracts (states of U.S.A. Delaware and Vermont);
- identification, notarial authentication, registration (Estonia);
- public security, supply network (Australia);
- real estate (Sweden);
- voting systems (Denmark, Ukraine);
- granting of land titles (U.S.A. Georgia).

[129] https://www.repository.cam.ac.uk/handle/1810/278893 [Access: May 2020] [65]

The advantages of this development have also been noticed in Poland. The Polish Credit Information Bureau (BIK S.A.) announced in May 2018 that it would place the registers of client accounts of Polish banks, shareholders of BIK, in the blockchain environment as the first country in the world[130]. In 2019, the Billon capital group, which cooperates with BIK in this respect, obtained a licence from the Polish Financial Supervision Authority (KNF) to carry out operations on electronic currency (e-money) throughout the EU[131].

The functionality of Blockchain covers an increasingly wide range of the market worldwide, in addition to secure exchange of information over the network, secure remote asset management and their sensitive data in IoT (Internet of Things) and secure online payments, as well as the functionality of the so-called Smart Contracts[132], i.e. computer verification of contract data in civil-law contracts.

5.6.2.4 Training as a service

Periodic training in business and public entities should be carried out as a commercial service by external cyber security specialists with the participation of local IT specialists of the company. Such trainings, in addition to analyses of data security methods, should also include test digital intrusions for practical testing of the entire digital security system in each company or institution.

The form of the service should entail the responsibility of a trainer for the cyber security improvements proposed in the specific case and for the confidentiality of all information protected during the performance of the service, not only sensitive information.

According to the PwC report of 2018, the need for such services is widespread.

5.7 Lean ecosystem

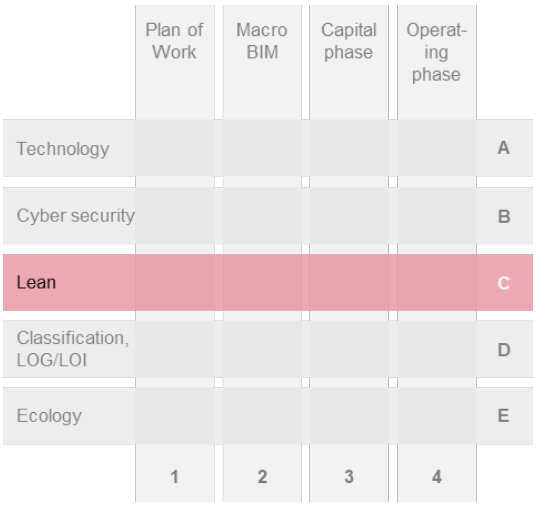


Figure 45: Lean, the third element of the matrix in terms of its substance, also means bottom-up processes.

Own elaboration

5.7.1 Legal and regulatory ecosystem

- There is neither a normative nor a legislative basis for this ecosystem. However, Lean methods do work. More and more branches of economy of many countries in the world introduce this system into their

[130] https://www.prnewswire.com/news-releases/poland-becomes-worlds-first-to-put-banking-records-on-the-blockchain-682528431.html [Access: May 2020] [123]
[131] https://pl.wikipedia.org/wiki/Billon [Access: May 2020]
[132] https://en.wikipedia.org/wiki/Smart_contract [Access: May 2020]

processes despite many critical attitudes towards the lack of measurable efficiency criteria of Lean methodology, detailed descriptions of data collection and evaluation or documented case studies;

- One of the most important documents developed to establish a link between Lean methods and construction processes is the document published in London in 2013 by Construction Industry Research and Information Association (CIRIA) "**Implementing Lean in construction. Lean construction and BIM**" [44]. It is one of a series of documents (CIRIA Lean guides, no. 725), dealing with the implementation of Lean methods in various branches of economy. There are also other documents of this type;
- In order for Lean tools to be fully applied for monitoring life costs of the investment asset (especially TVD – Target Value Design, described in section 5.7.2.12) for Polish public investments, the correct definition of the methods for calculating these costs should be carried out as soon as possible. The existing tool for this purpose - **Regulation of the Minister of Investment and Development of 11 July 2018 on the method of calculating the life cycle costs of buildings and the manner of presenting information on these costs (Journal of Laws 2018, item 1357)**[133] requires an amendment to specify the calculation methodology and guidelines for presenting information on these costs.
- The amendment should include: 1. Extension of the list of proposed elements of facilities to all elements important from the point of view of life-cycle costs (especially teletechnical systems, CCTV, building automation, sensors for digital twins), 2. Use of examples to illustrate the requirements, 3. Presentation of a realistic method of calculating these costs and not e.g. the range of life cycles 1-10 (or 1-15) for unspecified 'other' elements, 4. Definition of methods for presenting these costs (e.g.: graphical, diagramatical, tabular), as in the title of the Regulation.

5.7.2 Description

The term "Lean Construction" first appeared in 1992 (Lauri Koskela[134]). The critical point of Lean thinking is to focus on values: *„Often however, value creation is seen as equal to cost reduction. This represents a common yet critical shortcoming of the understanding of lean*."[135][136]

Over the years, the Lean Construction system has been understood as a set of tools and practices aimed at reducing losses and introducing a production control method called Last Planner® System into construction processes, as it is considered to be a set of concepts, principles and tools based on TPS (Toyota Production System) literature, such as pull planning, source analysis of defects and many others. However, there is no established strategy or nor normative documents in Japanese sources, hence the aforementioned lack of Lean standardisation.

Lean Construction is an adaptation of Lean methods and tools already used in industry under the names Lean Industry or Lean Manufacturing (Lean Thinking + Industry 4.0). An additional contribution is a number of methods specially designed for the construction industry by the Lean Construction Institute[137] and proposed with a new name. Many scientific studies also propose a new version of the name, enriched with sustainable experiences: SLC (Sustainable Lean Construction)[138].

Lean Construction is one of the methods of managing construction processes, and it differs from others (such as PMBOK[139], PRINCE2[140] or Simultaneous Management) in terms of greater dynamics, leaner bureaucracy and a holistic approach, hence its growing popularity.

The characteristics of the Lean Construction methodology are summarized in the table below:

[133] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20180001357/O/D20181357.pdf [Access: May 2020] [72]
[134] https://www.leanconstruction.org/media/docs/Koskela-TR72.pdf [Access: May 2020] [66]
[135] Ang.: "Often, value creation is associated with cost reduction. This represents a common criticism that is a false simplification of the way Lean is understood."
[136] https://www.leancompetency.org/wp-content/uploads/2015/09/Learning-to-Evolve.pdf [Access: May 2020] [67]
[137] https://en.wikipedia.org/wiki/Lean_Construction_Institute [Access: May 2020]
[138] https://www.sciencedirect.com/science/article/pii/S1877050916323730 [Access: May 2020] [96]
[139] https://pl.wikipedia.org/wiki/Project_Management_Body_of_Knowledge [Access: May 2020]
[140] https://pl.wikipedia.org/wiki/PRINCE2 [Access: May 2020]

Table 7: Characteristics of Lean Construction methodology. [45]

Theory	Rank of planning	Planning process	Incidents management
Lean Construction is based on production theories Adapts TFV (Transformation - Flow - Value) and Lean Thinking models Treats construction as a unique project, on-site production and temporary multi-organisation	It integrates the approach: "planning management" with the approach: "managing the organisation" Promotes work structuring and production planning systems	Promotes production planning and focuses on workflow stabilisation	Treats project management as an incident reduction It assumes that, in practice, some incidents are caused by poor order and bad decisions It assumes that incidents can be managed and focuses on the reduction of variables before production (delivery)

Adaptation of Lean tools, based on the Toyota Production System (TPS) philosophy, is progressing in construction worldwide and should not be underestimated. Additionally, one of the Lean tools called PDCA has already found its way to the PN-EN ISO 19650-1:2019 standard, and the text of the standard mentions the so-called "continual improvement", which is the basis of the Lean Kaizen method, consisting of countinual improvement of activities, procedural steps and entire processes.The PDCA is gradually being recognised as the basis for any process management method (Kevin W. Knight - 'ISO 3100:2009; ISO/IEC 31010 & ISO Guide 73:2009, International Standards for the Management of Risk'). [46]. The graphics below are from the above presentation.

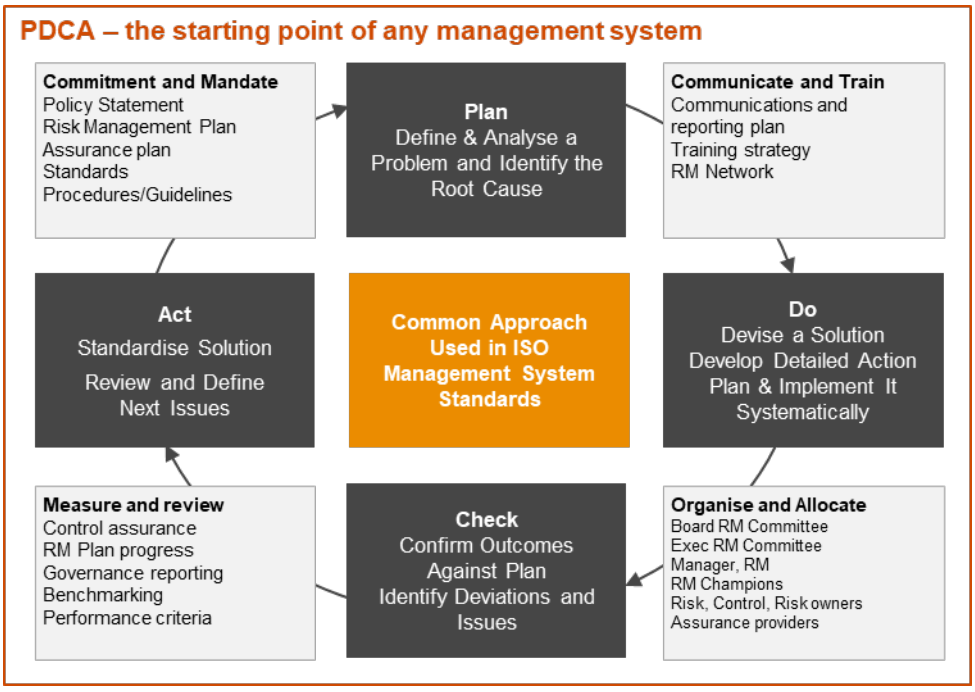


Figure 46: PDCA (Plan-Do-Check-Adjust) operation diagram as the basis for management systems. [46]

The basic and necessary aspects of Lean methodology in production processes are:

- Early integration of all participants;
- Co-location in one place (big room);
- Technology support;
- Visualization of the idea of the process.

Lean for industry and construction includes the following tools discussed later in this document:

- Visual labelling and 5S visual workshop (paragraphs 5.7.2.1 and 5.7.2.2);
- Value stream mapping (point 5.7.2.3);
- Strategy A3 (point 5.0);
- Elimination of 8 sources of waste - jap. "muda" (point 5.7.2.5);
- PDCA strategy (point 5.7.2.6);
- 5xWhy? (point 5.7.2.7);
- Agile and Scrum elements (paragraphs 5.7.2.8 and 5.7.2.9);
- Fishbone diagram (point 5.7.2.10);
- Target Value Design (point 5.7.2.12);
- Choosing by Advantages (point 5.7.2.11);
- Last Planner® System (paragraph 5.7.2.13).

The last three tools were prepared especially for construction processes, and the last one even received a registration mark registered by the Lean Construction Institute.

In the Polish construction industry, several factors can be identified which make it difficult to fully apply the Lean methodology, e.g:

- procedural and contractual factors;
- cultural and behavioural factors;
- separation of design/construction processes;
- lack of support from high-level management;
- lack of focus of the executive team on quality for the appointing party and on process value.

It can be assumed that with the progress of the BIM methodology it will also be easier and easier to implement Lean (BIM is sometimes presented as one of the elements of Lean) in the process of information exchange and professional development that the integrated methodology requires. Nevertheless, consistent education of all construction entities at all levels of their involvement in the implementation processes should become a permanent requirement.

The aim is to change the awareness of investment processing from the traditional approach to full integration and cooperation. It is a difficult task because it requires a change of mentality and is the greatest unknown in both investment processes in the construction industry and in every type of activity in societies.

The functionality enabled by Lean tools developed especially for the construction industry (Target Value Design, Choosing by Advantages and Last Planner® System) is the best "bottom-up" response to the "top-down" requirements for integrated processes contained in the PN-EN ISO 19650 standard series and other standards. This will facilitate the convergence of the two lines of action for better cooperation and mutual understanding through a complete visualisation of the entire design and execution process.

5.7.2.1 Visual labelling

It consists in labelling the places where tools are available at the workplace with a short description. The aim of this activity is to create a bridge between the mental model of work and its reality, illustrate the physical "What?" and facilitate the task "How to do it? In addition, it helps to create an impression of obviousness and to dispel ambiguity, allowing quick decisions to be made, including those by colleagues.

5.7.2.2 5S (visual workplace)

5S is a way of organizing one's own workplace by knowing where each tool is sorted and at the same time sharing this knowledge with other co-workers.

The system consists of 5 actions whose names start with the letter "S", also in Polish (hence the tool name):

- **Sorting of objects** at the workplace;
- **Setting in order** - finding places for these objects (+ labelling from the previous tool);
- **Shine** - daily storage of these facilities;
- **Standardization** - establishing these activities as a daily rule;
- **Sustain** - maintaining that order.

5.7.2.3 Value Stream Mapping

This is one of the most important tools to improve production processes. It consists in analyzing faulty procedures and finding the correct steps for them to remove negative effects. This process consists of 7 actions:

- Identification of the defective agent within the production process;
- Definition and recording of all related objects and entities;
- Writing down the faulty procedure step by step and passing the report on to all parties;
- Recording of the procedure with all activities in FlowChart;
- Identification of the time needed for faulty actions and collection of feedback from all actors;
- Developing a new procedure to eliminate defects;
- New FlowChart with a record of the differences between the two procedures.

In some studies, on BIM and Lean, it is recommended to establish for construction investments the role of **the Value Stream Mapping Manager** for the need to analyse the implementation of procedures, corrective actions and implementation of new, improved flows. This is a good method of bottom-up control of BIM processes, described and recommended top-down in standardisation documents.

Below is an illustration of an exemplary diagram of investment processes in the construction industry, made using symbols and icons of VSM mapping (presented in point 5.2.2.1). There are electronic tools for this purpose, but analogue use of tables or even sheets of paper on the wall with *post-it* cards, showing elements of the process, is also widely used.

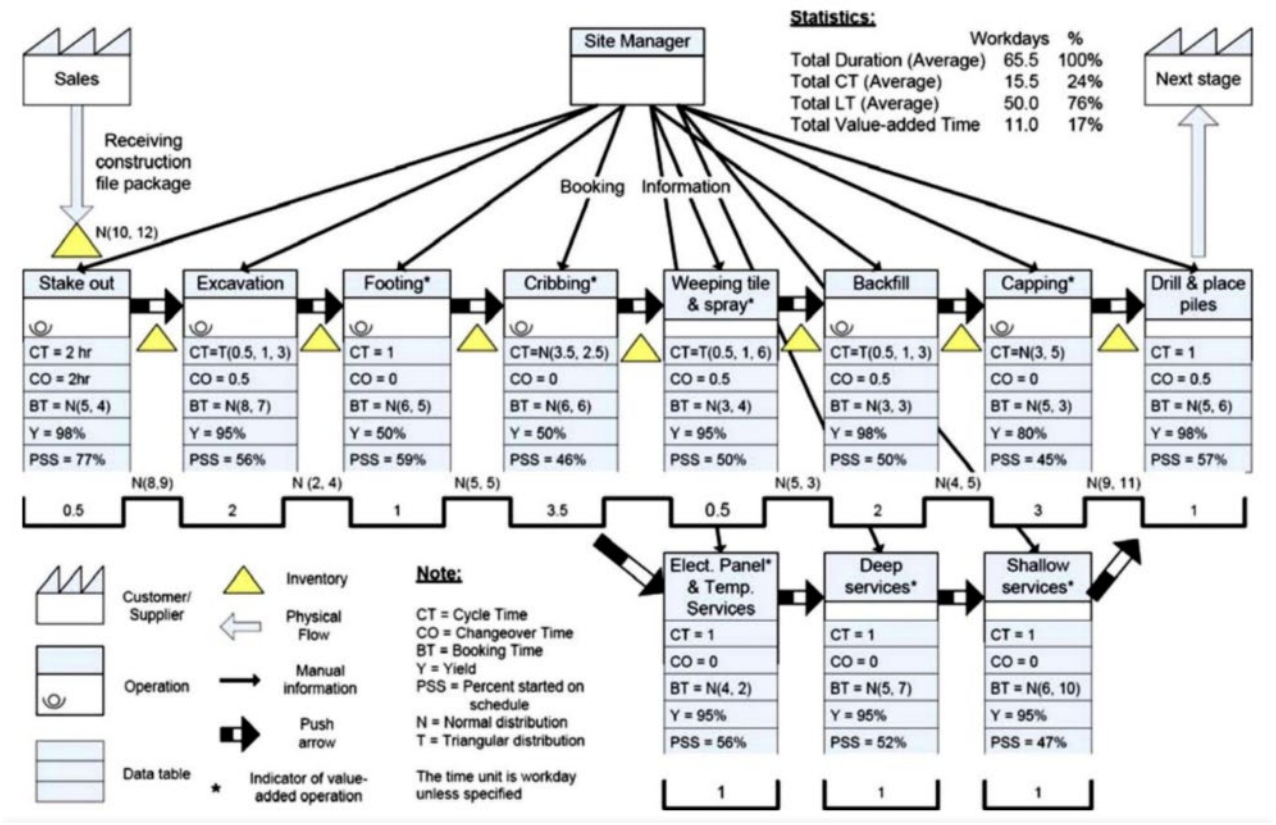


Figure 47: Electronic use of the Value Stream Mapping symbols to create a construction process diagram to correct them. [47]

5.7.2.4 A3 Strategy

It consists in recording the whole company strategy with action projects on one A3 sheet (hence its name). A3 strategy can also be recorded for a specific action or task, not only for global development directions, its application is universal. It consists of several points:

- Definition of the company's development direction;
- Definition of the distance between the company and the goal;
- Establishment of intermediate targets to reduce this distance;
- Definition of actions for achievement of intermediate goals.

5.7.2.5 Elimination of eight sources of waste (jap. "Muda")

A key tool in the Toyota Production System strategy and the essence of the entire Lean direction: **REDUCTION OF WASTE IN PRODUCTION PROCESSES**. Other objectives were added to the original strategy in later years. The processes specified 8 types of waste:

- Overproduction – e.g. involvement of many teams in the development of concepts / offers for open tender procedures;
- Stocks – e.g. overestimation of demand for materials (delivery stage) due to accepted safety factors and/or loss rates (inadequate to actual needs);
- Quality defects – e.g. collisions on projects, inconsistencies between industry projects, introduction of design changes at the stage of investment implementation at the expense of the quality of the final product (to achieve savings);

- Unnecessary movement - e.g. lack of coordination of work carried out by different units / contractors (duplication of the same activities by different contractors), lack of structured data storage models and file naming systems (project documentation), need to search binders and/or catalogues for relevant information (including their revision);
- Unnecessary transport – e.g. no detailed planning of delivery logistics (e.g. planning of delivery schedules in relation to maximum vehicle load capacity in order to optimise the number of journeys as much as possible);
- Repeating, overprocessing – e.g. extensive approval chain e.g. reports, documentation;
- Waiting – e.g. excessive bureaucracy (waiting for a decision or approval), planning and logistical mistakes (waiting for delivery of materials for construction);
- Human potential – e.g. inadequate use of human potential. Failure to use unique skills or knowledge of employees. Not considering employees' ideas and suggestions in improving processes and reducing waste.

5.7.2.6 PDCA strategy (Plan-Do-Check-Adjust/ Act)

The most popular tool from the Lean palette is present in everyday process management practice as well as in the text of BIM standards from the ISO 19650 series. It is one of the best methods of implementation and testing of procedures in execution processes independently of the business sector. The PDCA tool was created to control quality in the PAM (Physical Asset Management) physical environment.

As an example, both the British management standard PAS 55 and the derived ISO 5500X series of standards have been recorded as one page in PDCA format in a South African university study "Correlating the content and context of PAS 55 with the ISO 55000 series". [48].

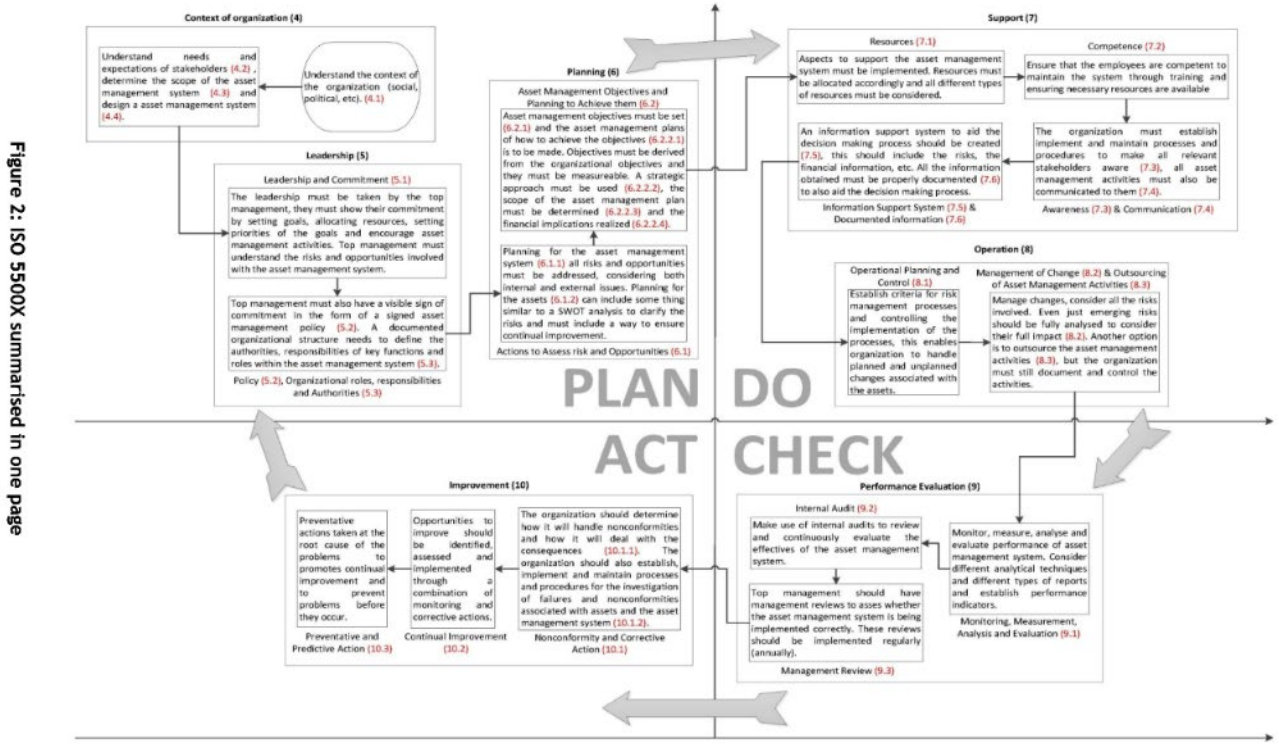


Figure 48: A diagram of the ISO 5500X series of standards presented as a single page in the PDCA method record. [48]

Here are the PDCA components:

- P (Plan) – identification and analysis of the issue;
- D (Do) – solution definition and its implementation;
- C (Check) – a check of the implementation of the results (feedback);
- A (Adjust, sometimes also known as Act) – correction of a proposed solution and creation of a standard from it.

5.7.2.7 5xWhy? (5xWhy?)

Although it resembles a series of questions asked by children, it is a recognized professional tool for the analysis of the essence of a defect occurrence in processes. It consists of an iterative technique of questioning with the phrase: "Why?". Most often an answer to the fifth such question reveals the source of the defect. Effects (answers) are recorded either as a Fishbone Diagram (see also section 5.7.2.10) or in tabular form.

The 5xWhy? question system was developed by Toyota's chief engineer, Taiichi Ohno.

5.7.2.8 Agile (methods of operation)

It is not a typical Lean tool, but due to its efficiency and similar features it can be considered as Lean-like. Agile was developed in response to PMBOK and PRINCE2 management systems, which have been present on the market for a long time, but which are relatively rigid and bureaucratic methods of conducting production processes.

Agile is particularly suitable for processes that are sometimes unpredictable, such as in the construction industry, but also works well in continuous operation procedures. The system comes from software development. Agile breaks down larger projects into small, easily manageable fragments called iterations (with repeatability in time loops). The system groups all participants of the process in order to work out the greatest value for the customer by means of cost control, quality and procedural transparency. Open communication, dedicated teams and good planning are the guarantee of success.

The Agile system has several characteristics that constitute its essence:

- Cooperation;
- Intensive knowledge sharing;
- Teamwork;
- End-user involvement (**FOCUS ON CUSTOMER NEEDS**, as opposed to Lean in production, which focuses on waste reduction);
- Early acceptance of design solutions;
- Production and supply of partial contents (iterations) of the product.

5.7.2.9 Scrum

Agile derived system (also derived from software programming), consisting of project management by dividing the process into short ranges, called sprints, to which Lean methods such as PDCA are applied. The difference from the usual, continuous and linear production process, referred to as waterfall (or cascade process) is the introduction of sub-processes for easier management and for obtaining specific results in the form of completed stages of the final product / asset creation.

5.7.2.10 Fishbone diagram

A tool known for its production processes all over the world. The diagram was created by Japanese management theorist Kaoru Ishikawa[141]. It visually depicts the sources of defects in the form of a cause and effect system of the main and secondary causes of defects, leading to the occurrence of the analysed defect (depicted as a fish head).

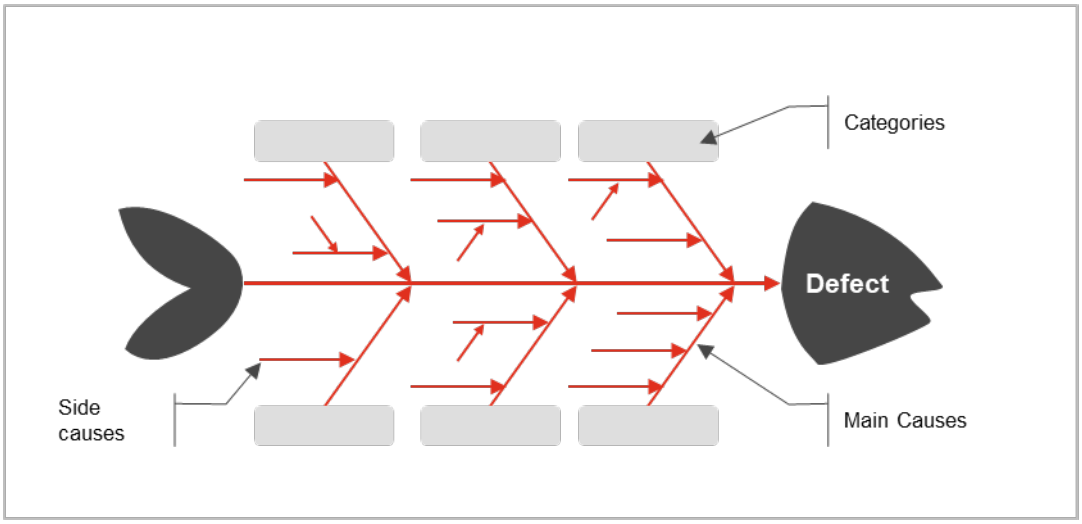


Figure 49: Fishbone diagram.

Own elaboration based on[142]

The analysis of causes begins with the determination of the effect (defect), leading down to its causes, covering all possible causes of the defect. There are 5 main categories of causes and environmental conditions (known as 5M + E): Manpower (people), Methods, Machinery, Materials, Management and Environment.

5.7.2.11 Choosing by Advantages (CbA)

This is a decision-making method based on the criterion of the greatest possible benefit. A characteristic feature of this management system, derived from Jim Suhr's work[143], is a structured decision-making method. The decision is based on the degree of importance of its benefits, and tools such as A3 strategy analysis and feedback from the Integrated Team are used to make it. In this system, decisions are also documented for future reference. The CbA tool has several process steps that are used in a loop (see illustration below):

- Identification of alternative suggestions;
- Definition of factors;
- Definition of criteria: "we need it / want it" for each of the factors;
- Description of the attributes of each of the alternatives;
- Identify the benefits of each option;
- Decision on the validity of each benefit;
- Evaluation of costs.

[141]Kaoru Ishikawa (1915-1989) - Japanese theoretician of organization, graduate of the Faculty of Engineering at Tokyo University
[142]https://goleansixsigma.com/fishbone-diagram-aka-cause-effect-diagram/ [Access: May 2020] [97]
[143] Jim Suhr - co-founder and president of IDI (Institute for Decision Innovations) - Institute of Decision Innovation - https://www.decisioninnovations.com [Access: May 2020]

This tool is optimally used when analyzing alternatives in another Lean tool: Target Value Design, described in the next section.

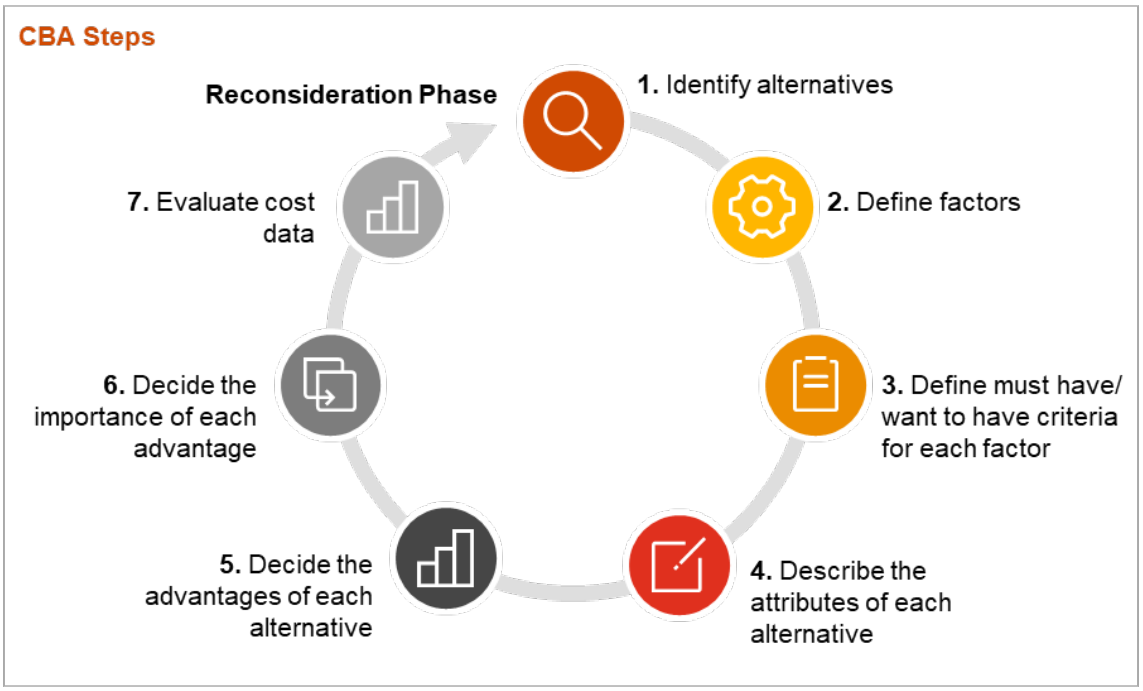


Figure 50: Cyclical decision-making process, based on the highest value.

Own elaboration based on[144]

5.7.2.12 Target Value Design

Beside the Last Planner® System, this is one of the two most important Lean tools developed especially for the construction industry.

It is used for monitoring the Target Cost (see MacroBIM phase - point 5.2) in the form of selection of the best alternative solutions for the entire life cycle cost of the investment, when there is a need to make adjustments to the flow of funds from the investment budget. This is the case, for example, when for some reason it is necessary to apply a more expensive solution in one place - then the task is to find an optimal cheaper solution in another place. The responsibility is the Target Cost with its incentive cushion, so also the interest of each member of the Core Group.

The TVD differs from the common Value Engineering on Polish construction sites (looking for the cheapest solutions, mainly for the benefit of the general contractor (lead appointed party), usually to share the surplus with the appointing party) in that the decisions are qualified, made jointly with each member of the group with the help of a validation tool, selection in terms of the greatest benefit (CbA), and the solution is selected from a pool of options acceptable to all. If there is a clear opposition from the appointing party, it may be necessary to revise the Target Cost.

THE CHARACTERISTIC FEATURE OF THE TARGET VALUE DESIGN APPLICATION IS THEREFORE THE CONSTANT PRESENCE OF ALL PARTICIPANTS OF THE INVESTMENT PROCESS FROM THE CORE GROUP UNTIL THE ASSET IS HANDED OVER FOR USE. This is a process, different from the so-called author's supervision, when individuals appear sporadically and periodically on the construction site for coordination meetings or solving identified anomalies. A change in the financing of processes in the BIM methodology must also take into account the expenditure on this

[144] https://leanconstructionblog.com/applying-choosing-by-advantages-step-by-step.html [Access: May 2020] [98]

cooperation, which is aimed at optimising the design solutions and thus saving the appointing partythe costs of operating the investment asset in the future.

TVD is a continuous process and consists of 3 main parts, the condition is a defined Target Cost and a formed team from the Core Group decision making:

- Identification and analysis of the cost-intensive element/system;
- Commonly accepted definition of a solution based on possible alternative options (using the CbA tool) and its implementation;
- Check of the implementation of the results with further cost analysis. Budget monitoring involves both rapid (ad hoc) and thorough control of cost flow.

TVD is thus a cost estimation tool by continuously monitoring the current cost of the investment. The difference between traditional cost estimation (each time after the Schematic Design, Design Documentation and Execution Documentation stages) and the TVD system is visually presented in the graphics below. The **TVD is only possible for the actual, not only declared, transparency of the project and processes**.

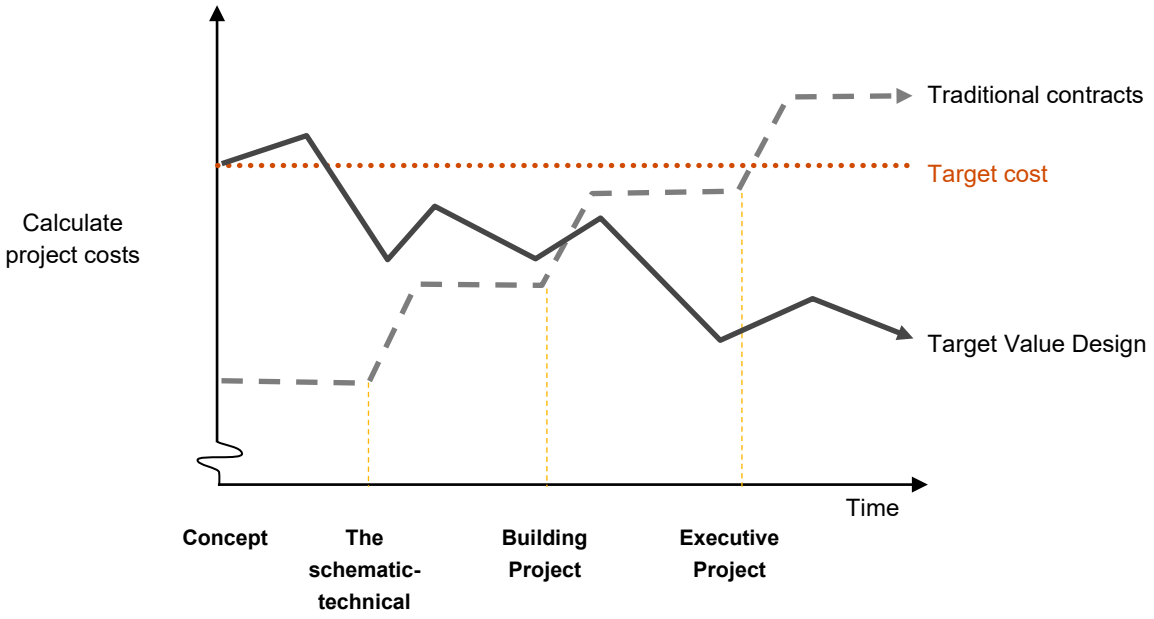


Figure 51: Comparison of the application of cost calculation in a traditional process and using Target Value Design.[145]

The second task of the designers at the stage of Target Value Design cooperation is to update the AIM model[146] (matching the IFC exports of the industry models to the state consistent with the physical condition of the object). The AIM model, in addition to the asset itself, is the main purpose of the task of creating and delivering the asset according to the PN-EN ISO 19650-2:2019 standard.

5.7.2.13 Last Planner® System

In addition to TVD, it is the most important tool from the Lean palette for construction processes. It is based on a Lean tool for production called Project Scheduling (PS), which provides for a system of execution process schedules of different time granulation. The aim is to develop cooperation and teamwork for the win-win model (everyone wins). A set of Project Scheduling schedules includes:

- Master Schedule - the main plan of investment realization;
- Six-Week Schedule - a 6-week plan, with flashbacks and revisions to introduce new tasks;

[145] https://leanconstructionblog.com/Introduction-to-Target-Value-Delivery.html [Access: May 2020] [122]
[146] AIM model see point 5.4.2.1

- Weekly Schedule - a specific action plan for a week;
- Weekly Scorecard - a weekly report after each weekly plan;
- Separate review of continuous improvement (CI - Continuous Improvement) - The term also appears in the text of BIM -PN-EN ISO 19650-2:2019, point 5.2 of the text).

Based on the above schedule system, the Last Planner® system was created especially for the construction industry by specialists from the Lean Construction Institute. LP®S schedules can be used as tools for the implementation of TIDP and General MIDP task plans, as they visually and clearly introduce task teams into investment activities. The plan system includes:

- MASTER SCHEDULE – the main investment realization plan, similarly as in the Project Scheduling system - corresponds to the MIDP - Master Information Delivery Plan (standard PN-EN ISO 19650-2:2019, point 5.4.5 of the standard text);
- PHASE PULL PLANNING – this is a division of the Master plan into 12-16 week phases, monitoring the implementation of tasks in the PDCA method, using this time frame to check the functionality of solutions before they become a standard;
- SIX WEEK LOOK AHEAD – a 6-week plan (which is a subdivision of the Phase Pull plan), undertaken with a recorded commitment of performance by the task teams;
- WEEKLY WORK PLANS – concrete delivery of promises from the 6-week plan for each week, monitored by the PPC (Percent Promises Completed) table, i.e. the percentage of commitments fulfilled. Each weekly plan is set up in a form of one stiff, movable table in the construction office (there are 6 of them in total for the whole 6-week plan, standing next to each other) with a vertical division into individual days. In the fields of the days, members of task teams indicate (usually using *post-it* cards) the tasks to be completed and the completed ones - similarly to the visual procedure of Scrum tasks (this is also a form of recording the tasks required for TIDP - Task Information Delivery Plan, standard PN-EN ISO 19650-2:2019, pt. 5.4.4 of the standard text). Such a way of visualizing activities on time-divided boards is called the Kanban method[147], and was developed by Toyota in the 40s of the last century. For the next new 6-week plan, the boards of the previous planus are removed to the archive (or archived in another way, e.g. digital) so that there are always 6 boards for the current 6-week plan. This is the best method of bottom-up "push" organization for the implementation of the requirements of the BIM standard, written in the series of standards PN-EN ISO 19650 (treated as "pull");
- DAILY HUDDLES – these are meetings before and / or at the end of the working day with a summary of the implementation of tasks throughout the day.

THE MOST IMPORTANT ADVANTAGE OF LAST PLANNER® SYSTEM IS THE METHOD OF PREPARING TASKS TO BE PERFORMED. IT IS BASED ON COOPERATIVE PLANNING, ANALYTICAL APPROACH TO THE IMPLEMENTATION OF TASKS AND COLLECTION OF REALISTIC COMMITMENTS OF DELIVERY, WHICH MAKES THEM FEASIBLE.

LAST PLANNER® SYSTEM IS NOT A PROCESS THAT WOULD DIFFER FROM THE TRADITIONAL CONSTRUCTION IMPLEMENTATION STAGES, HOWEVER, ITS ESSENCE AND STRENGTH IS THE WAY THE IMPLEMENTATION TASKS ARE PREPARED AND HANDLED IN A COOPERATIVE ENVIRONMENT.

In case of failure to keep the committments, the use of e.g. Lean 5xWhy? tool can easily lead to the detection of the cause and permanent elimination of the defect by registering it. Last Planner® should start for detail planning as soon as the investment is started, after division of Master Plan into its components. Properly prepared Weekly Work Plans:

- They should have well-defined weekly work schedules with all required tools and resources;
- All anticipated constraints should be previously identified and removed in a cooperative process;

[147]Kanban is a method that consists in visualizing the activities to be performed, limiting the set of activities, managing a smooth workflow, defining and socializing elements of the process, using cyclic feedback and improving cooperation. Source: https://kanbanize.com/kanban-resources/getting-started/what-is-kanban [Access: May 2020]

- The work to be done should be set in a correct sequence;
- Individual works should be scaled up to the performance capabilities of the task teams.

The graphics below summarize all types of time plans of the tool with a list of types of commitments related to their implementation.

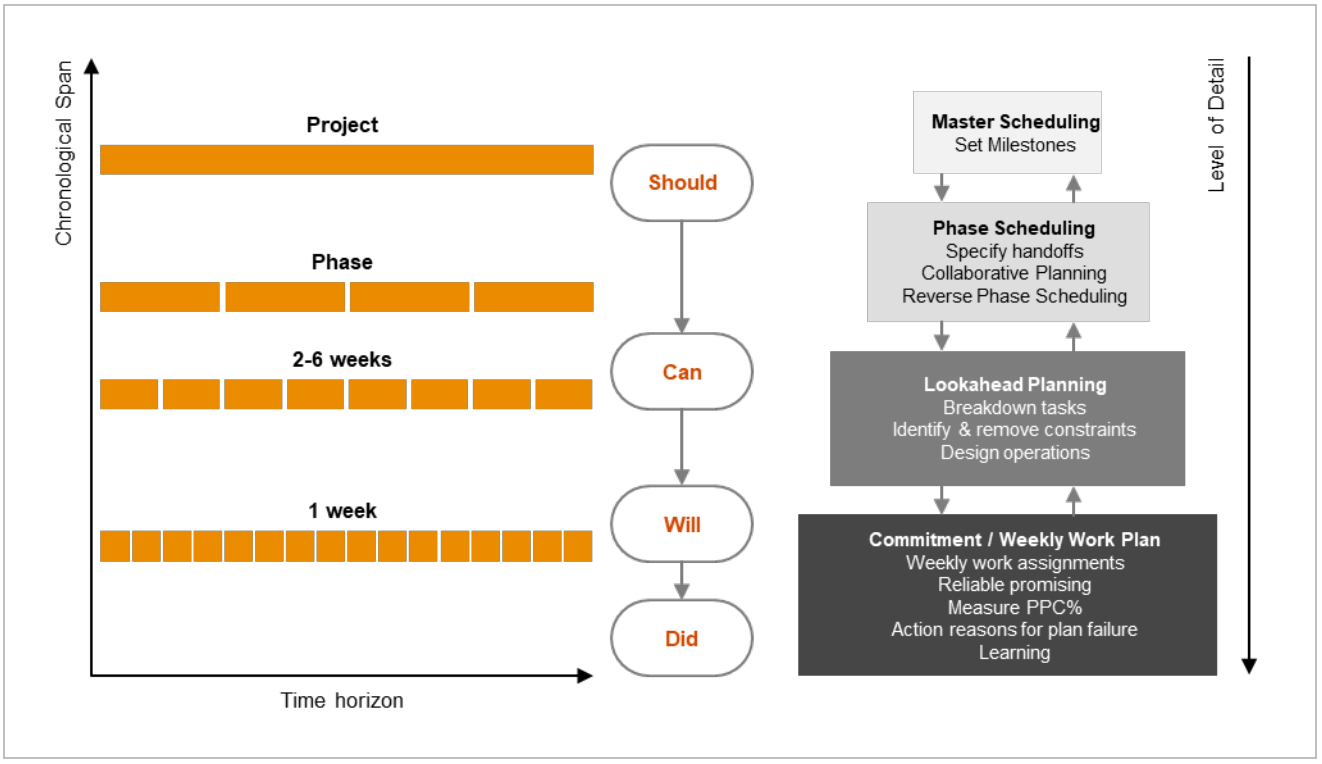
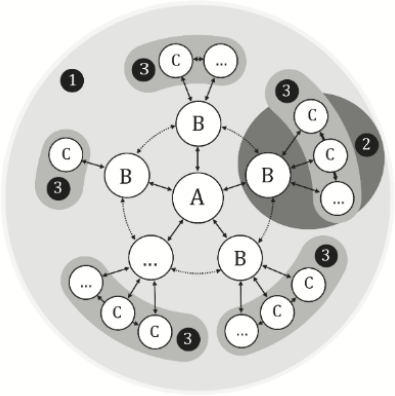


Figure 52: Graphical representation of all Last Planner® System for Production Control schedule types (full method name) [49]

The list, included in this chapter, does not exhaust all Lean tools, but presents the most important ones. In general, the Lean system should be introduced from the very beginning, after the formation of the decision-making Core Group (A + B in the graphics below), the extended Integrated Team (A + B + C) and the allocation of of task forces.

These tasks and their structure also correspond to the methods of structuring the organization of the entire investment, as described in the BIM standards (ISO 19650 series) (graphics from the text of the standard below). The aim is to create harmony in the form of introducing an equivalent of a bottom-up organization for top-down requirements imposed by global, but also Polish standards for BIM. In this way, it will be the easiest way to obtain the basis for the necessary cooperation of all participants in construction processes carried out in the BIM methodology.



Key

A	appointing party
B	lead appointed party
C	appointed party
...	variable amount
1	project team
2	illustration of a delivery team
3	task team(s)
◄►	information requirements and information exchange
◄··►	information coordination

Figure 53: Illustration of the Integrated Team structure[148]

The comparison of relations in Last Planner® System (graphics below) with the elements of the above graphics from the BIM standard in force in Poland shows great structural similarities. Both systems are compatible with each other, which facilitates the integration of top-down and bottom-up activities for optimal results.

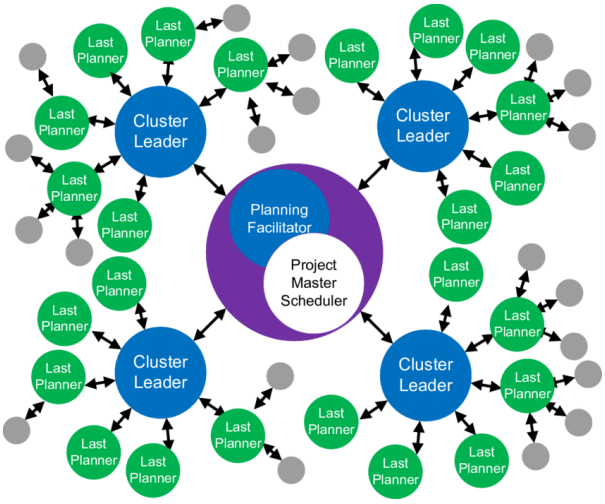


Figure 54: Illustration of the structure of the Integrated Team in the Lean methodology (Last Planner®). [50]

Thanks to its ability to visualize and plan tasks, Last Planner® System also works well in the design process. However, it requires the participation of all possible participants of the investment process in order to ensure the quality of developed design solutions and adopted systems for the future asset. The process starts with the definition of milestones and then goes on to a finer granulation of tasks solved like Weekly Work Plans in the implementation process. In the first phase, alternative options are jointly developed, which are then collectively eliminated (using the CbA tool) in the subsequent phases in order to reduce the set of variables and thus the associated uncertainty about the design solutions.

For the operational phase, there are both universal Lean tools, as well as a method to eliminate 8 sources of loss, and specially developed tools for this purpose. One of them is a combination of the Six Sigma method,

[148] Source: Standard PN-EN ISO 19650-1:2019

developed at Motorola[149] to eliminate defects in manufactured parts, with Lean methods to eliminate other defects in processes. This tool is called Lean Six Sigma and is designed to enable lossless asset management and servicing processes.

5.7.2.14 Training courses

The use of Lean methods should start with an introductory workshop. It is recommended to combine the Lean workshop with the initiating BIM workshop at the beginning of the investment process in order to create harmony in the activities and organisation from the top down, imposed by standards and norms, with the bottom up, resulting from the self-organisation and integration of the executive. This will allow to start cooperation and gain mutual trust.

5.8 Classification of objects and their saturation with information

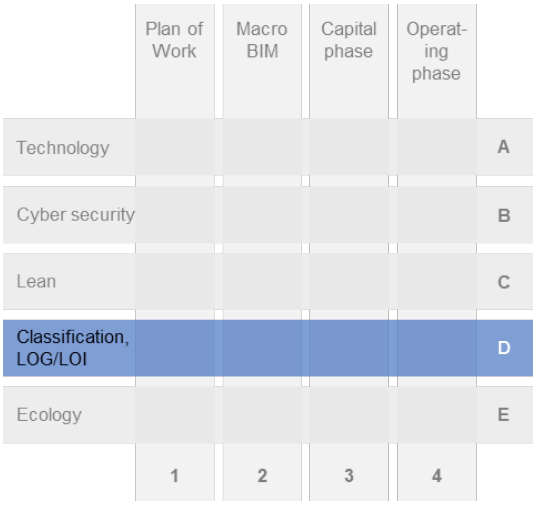


Figure 55: Classification (LOG/LOI) - fourth element of the matrix in terms of its substance.

Own elaboration

5.8.1 Legal and regulatory ecosystem

- Act of 11 September 2019 Public Procurement Law (**Journal of Laws 2019, item 2019**)[150], with particular emphasis on Articles 101-103 relating to the preparation of the description of the subject of the contract, including building works, including by reference to Polish Standards transposing European and international standards;
- ISO 6707-1:2017 (Buildings and civil engineering works - Vocabulary - Part 1: General terms) is a glossary of construction and engineering works terminology;
- Series of ISO 12006 standards (Organization of information about a building): **ISO 12006-2:2015** (Part 2: Framework for classification, Polish version of PN-EN ISO 12006-2:2005) - apart from ISO/IEC 81246-2 and ISO 81346-12 one of the three main standards on which classification systems in the construction industry are based for the BIM methodology; **PN-EN ISO 12006-3:2016** (Part 3: Object-oriented data schema), which is responsible for the standardisation of data exchange dictionaries such as IFD (International Framework for Dictionaries) and its further implementation of bSDD (buildingSMART Data Dictionary);

[149] https://pl.wikipedia.org/wiki/Sześć_sigma [Access: May 2020]
[150] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20190002019/U/D20192019Lj.pdf [Access: May 2020] [99]

- ISO 704:2009 (Terminology work - Principles and methods) - Basis for revision of ISO/IEC 81346-2, 2019;
- ISO/IEC 81346 series of standards (Industrial systems, installations and equipment and industrial products. Principles of structuring and reference designations): ISO/IEC 81346-1:2009 (Part 1: Basic rules); **PN-EN IEC 81346-2:2019** (Classification of works and class codes) - the second of three standards on which BIM building classification systems are based; ISO/TS 81346-3:2012 (Part 3: Application rules for a reference designation system); **ISO 81346-12:2018** (Part 12: Construction works and building services) - Part 12 of the 81346 series of standards, which includes m.Among other things, the whole technological systems used in construction, as opposed to Part 2, which deals with building elements and components, is the third basic standard for classification systems;
- Regulations for the construction industry, containing a reference to the CPV dictionary[151], when referred to the system of construction classification, including:Regulation of the Minister of Infrastructure of May 18, 2004 on determining the methods and bases for preparing the investor's cost estimate, calculating the planned costs of design works and the planned costs of construction works specified in the functional-utility program (**Dz.U. No. 130 item 1389**[152]; Regulation of the Minister of Infrastructure of 2 September 2004 on the detailed scope and form of design documentation, technical specifications for the execution and acceptance of construction works and the functional-utility programme (Journal of Laws **2013, item 1129**)[153].

  These Regulations are implementing acts pursuant to Articles 33(3) and 31. Paragraph 4 of the PPL [*Pol. Public Procurement Law*]. In connection with the entry into force, on 1 January 2021, of the New PPL, the above mentioned regulations should be replaced by analogous implementing regulations issued on the basis of the statutory delegation resulting from art. 34 par. 2 of the New PPL, which is the basis for determining, by way of a regulation, the methods and bases for preparing the investor's cost estimate and calculating the planned costs of design works and the planned costs of construction works specified in the functional and utility programme, taking into account the technical, technological and organisational data affecting the contract value and art. 103 Para. 4 of the New PPL - to determine, by means of a regulation, the detailed scope and form of design documentation, technical specifications for the execution and acceptance of works and the functional and utility programme, taking into account the type of works as well as the names and codes of the Common Procurement Vocabulary.

CIVIL ENGINEERING CLASSIFICATION FOR POLAND, WHEN IT IS CREATED, SHOULD BE CONSIDERED AT LEAST AS AN ALTERNATIVE TO THE COMMON PROCUREMENT VOCABULARY (CPV) IN THE ABOVE MENTIONED LEGAL ACTS, AND IN THE FUTURE - ITS SUBSTITUTE;

- Series of standards ISO 29481 (Building information models - Information delivery manual), both parts have already been issued as Polish standards **PN-EN ISO 29481-1:2017**(Part 1: Methodology and format) and **PN-EN ISO 29481-2:2012** (Part 2: Interaction framework). Both of the above-mentioned standards ISO 12006-3 and ISO 29481 together with the standard, standardizing IFC format (ISO 16739) form a triangle of relations for describing elements in construction objects created with the use of machines, i.e. by a computer. The following illustration from the resources of buildingSMART visualizes this concept, called "Three interoperability columns" (Three Pillars of Interoperability):

[151]CPV (Common Procurement Vocabulary) - Common Procurement Vocabulary, created on the basis of EU regulations in order to enable bids and construction investments to be made throughout the European Union. It refers to types and ranges of construction works but has nothing to do with the hierarchical information model in the BIM methodology.
[152]http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20041301389/O/D20041389.pdf [Access: May 2020] [101]
[153]http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20130001129/O/D20131129.pdf [Access: May 2020] [102]

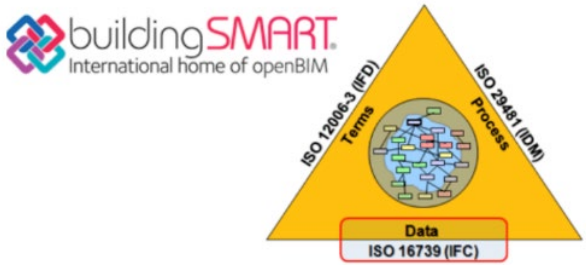


Figure 56: Structure of format, dictionary and information exchange methods in an Open BIM environment.[154]

This relationship also includes the following two ISO standards (No. 23386 and 23387), which describe data templates for manufacturers/suppliers and relate everything to the basic standards for BIM of the ISO 19650 series. The graphics are taken from a white paper report (by buildingSMART International, Cobuilder, GS1 and Construction Products Europe) from Digital Supply Chains in the Built Environment (DSCiBE), published in October 2019.

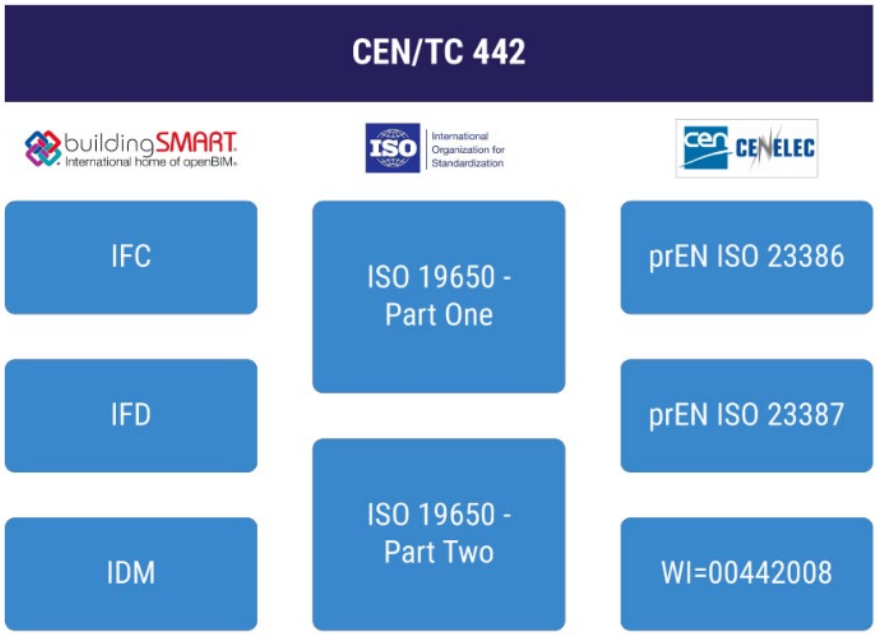


Figure 57: Structure of a set of standards corresponding to the information standard structure in Open BIM. [51]

- **ISO 23386:2020** standard (Building information modelling and other digital processes used in construction - Methodology to describe, author and maintain properties in interconnected data dictionaries) on the exchange of information about the digital version of the investment asset in construction between computer applications and digital formats, published in 2020;
- ISO/FDIS 23387 (Building information modelling (BIM) - Data templates for construction objects used in the life cycle of any built asset - Concepts and principles) with data templates for construction elements used in the life cycle of any built asset - the standard is under development;
- Horizon 2020 EU Digitisation Development Programme. One of its parts is the DigiPlace European Buildings Digitisation Platform (**H2020-EU.2.1.1**).

[154] http://www.bimmap.eu/en/bim-conseil/qu-est-ce-que-le-bim [Access: May 2020] [100]

5.8.2 Description

5.8.2.1 Construction classification

Classification systems for construction, including classification systems for BIM, are subject to standardization regulations. They can be divided into three groups in terms of their different characteristics. In each group there are two classifications with the opposite approach [52]:

A. Due to the application:
   - Analytical (a systematics of physical phenomena that provides a basis for explaining, predicting and understanding them, based on the separation of real objects or phenomena. An example is the classification of animal kingdoms, with rows, genera, species, etc.);
   - Documentary.

B. Due to the structure (number of division rules applied at each level):
   - Enumerative, otherwise: enumerative monohierarchical classifications (offer comprehensive, closed catalogues of classes and subclasses);
   - Faceted classifications, otherwise: aspectal or analytical-synthetic (polyhierarchical).

C. Due to the scope of application (volume of semantic field):
   - General, or else: universal, concern objects characterized by properties whose values are general and not limited to one object or investment process. Examples are parts of a building: wall, ceiling, etc;
   - Special or specialized, they focus on selected areas/objects. They concern objects characterized by properties whose values are limited to one object or investment process. An example of such a set of objects can be room numbers in a building.

Faceted classifications (Colon Classification) [52] allow only simple classes based on a single subdivision criterion, and for complex classes, simple class syntheses are used. This system has become the standard for all construction or infrastructure classifications worldwide.

There is a close link between the classifications and identifications of objects and products on the one hand, and the hierarchical structure of the whole construction project and its parts on the other. The structure of the hierarchical heritage of parameters, on the other hand, lies at the basis of both the BIM data transfer formats (IFC, BCF) [155] developed over the last decades and the information saturation levels of the modelled component objects.

It can be said that it is a coherent and integrated system, corresponding with its degree of advancement of the investment process, starting from project programming, through concept, design, execution to preparing assets for use in the business process. The following diagram presents schematically the above-mentioned relationships.

[155] Open formats for information exchange, developed by buildingSMART International

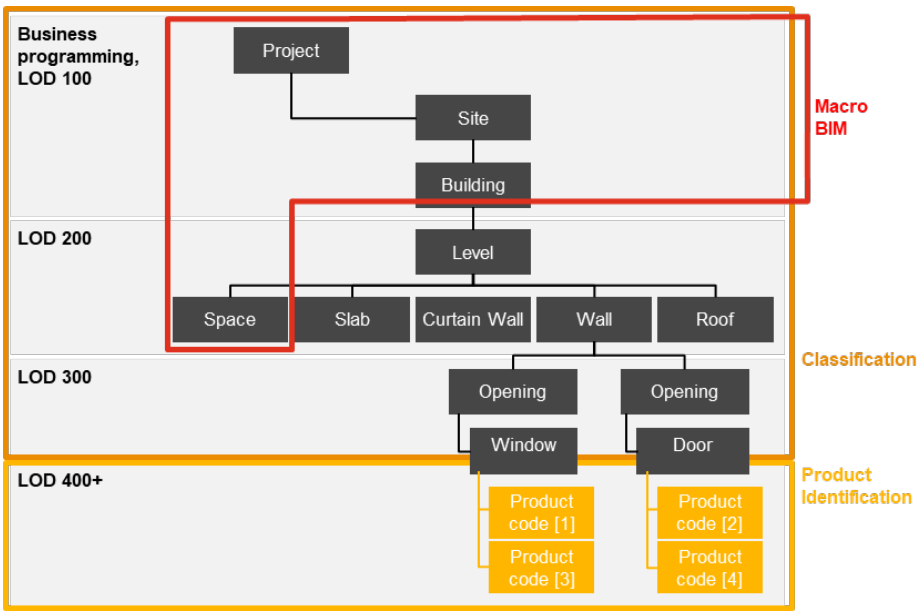


Figure 58 :Structure of IFC units in relation to the classification, identification and use area of information in the MacroBIM phase.[156]

The black rectangles illustrate the inheritance principle for IFC format entities, which is the basic design data carrier for geometry, topology and any related text data in the BIM methodology. The classification itself is a system that ends in the last step on no-name products (LOD 300 or 350 according to BIMforum), without identifying any manufacturer and his product, which corresponds to the required nature of public procurement.

5.8.2.2 Product identification

In order for the classification system to work practically and be helpful for all participants in construction processes, its elements and representations should contain a complete code from the root of the classification tree (information about the project and its location) to specific model objects and their physical counterparts. Order codes for physical products (LOD 400+ for identification systems) should also contain information on exactly where a given product is to be built in, based on the classification code from the project information model (PIM) with an added identification code. Only then the information is complete, understandable and useful for every participant of the investment process in any phase of the process, including operation and maintenance.

For the identification of products there are various systems, of which the largest global coverage is developed by non-commercial GS1[157]. GS1 codes for products are defined by e.g. GTIN (Global Trade Item Number) or SGTIN (Serialised GTIN) for product series. For the GTIN code to be able to unambiguously determine the product to be built into a physical object, purchased during the construction process, it must be connected using the so-called Digital Link with the type of product (no-name) from the classification system in force in Poland.

In order for the representation of a specific physical product to become part of the digital PIM model, and then the AIM, and consequently the Digital Twin for remote handling of a specific investment assets, the procedure involves mapping sets of information:

- First, a given element of the model, for which a particular product is to appear on the construction site, should be mapped to a construction classification system based on the hierarchy of IFC classes - the classification levels correspond to the IFC inheritance levels - **i.e. a given element, created in the model by a designer, receives a construction classification code**;

[156]Own elaboration, structure of IFC elements from www.buildingsmart.org
[157]https://en.wikipedia.org/wiki/GS1 [Access: May 2020]

- As the classification code for this item is compatible with its IFC data, the mapping to the bSDD format (this format is an implementation of the IFD format, based on ISO 12006-3:2007) (see the list of standards at the beginning of the chapter) to be able to referencing real-world products through the mapping matrix, which is the bSDD (buildingSMART Data Dictionary, created for buildingSMART by the Norwegian company Catenda). **The mapping is a process to combine both identifiers: for IFC and for bSDD**. The identifiers are in the form of Global Unique IDentifier (GUID) and are called IfcGuid and IfdGuid, since bSDD is part of the IFD set (ISO 12006-3);
- When the GUID of a design model element already has the IfdGuid added for mapping, among other things, the world of construction classifications and the world of physical products, it is possible to **"map" the product code, e.g. GTIN** (when we are dealing with the GS1 standard) **by assigning it to the bSDD GUID**. In this way, it is known where the product or material sent to the construction site is to be built in. The combination of these identifiers retains this information for the whole life cycle of the asset.

AS THERE IS NO SUCH CONSTRUCTION CLASSIFICATION FOR MAPPING PRODUCT CODES IN POLAND, A SMOOTH DIGITAL SUPPLY CHAIN PROCESS IS NOT CURRENTLY POSSIBLE.

THE ABOVE-DESCRIBED MAPPINGS ARE ALSO NOT POSSIBLE BECAUSE THERE IS NO CLOSE INTEGRATION OF THE MATERIALS AND PRODUCTS ORDERED FOR THE CONSTRUCTION SITE WITH THE REPRESENTATION OF THE INVESTMENT'S DESIGN MODEL, AND THUS NEITHER WITH THE PHYSICAL OBJECT NOR WITH ITS DIGITAL TWIN FOR LATER, REMOTE OPERATION.

Work on international coordination of digitisation and standardisation of the construction supply chain is carried out by several public and corporate entities (including GS1, CoBuilder, buildingSMART International, the Norwegian public asset management agency Statsbygg, CEN and ISO standardisation organisations and IBM, Siemens) within the framework of DSCiBE (Digital Supply Chain in the Built Environment), established in March 2019 [158].

[159]In September of the same year, the DigiPlace platform was established on the basis of an EU fund to develop a roadmap for the creation of a pan-European digital construction platform in the framework of ICT development in Horizon 2020 (H2020-EU.2.1.1).

5.8.2.3 Saturation levels of elements with LOD information

As can be seen from section 5.8.2.1, the classification codes are related to the degree of saturation of object information, called LOD (Level of Development). This information is divided into

- **LOG** (Level of Geometry) – this is a modification of the original sound for 2D/3D geometric and topological information as another LOD (Level of Detail - the original form of the name), the correction has been proposed in many documents around the world (including Czech strategic studies, other German and Swiss studies) to avoid confusion between the two concepts of LOD;
- **LOI** (Level of Information) – alphanumeric (text) information.

The basic structure of saturation of objects with information assumed five levels:

- LOD 100 – corresponds to the conceptual, programming model;
- LOD 200 – corresponds to the schematic design phase;
- LOD 300 – corresponds to the detail (construction) project phase;
- LOD 400 – corresponds to the executive (technical) design phase;
- LOD 500 – corresponds to the As-Built phase (of the constructed object).

Elements of the model, such as walls, ceilings, windows, doors, stairs, installation ducts, cable routes, air handling units or built-in or movable equipment, etc. do not appear in the models from the LOD 100 level

[158]https://cobuilder.com/en/about-the-digital-supply-chains-in-built-environment-dscibe-work-group/ [Access: May 2020] [103]
[159]https://www.digiplaceproject.eu [Access: May 2020]

onwards, but in their respective further design phases. Therefore it is not necessary to model them in all LOD levels - three (sometimes even two, without scheme stage) are enough, according to the following practical application for required milestones of model geometry (for stages of LOI text information additional subdivisions may apply, proposals of "data drops" (the so-called Data Drops) are the scope of another part of this project ("Building investment management in BIM methodology - proposal of document templates").

- **1st Data Drop** (to be accepted by an appointing party and for further negotiations of the Target Cost in the MacroBIM phase)**: information on massing models of form or function (+ indicative costs) LOD→ 100** (without presenting any construction elements except blocks**)**;
- **2nd Data Drop** (to be accepted by an appointing party)**: reduced information on the LOD200→ schematic design level** (schematic representation of only some building elements relevant for illustrating the functional and formal layout diagram);
- **3rd Data Drop** (to be accepted by an appopinting party)**: more precise information on the level of the LOD300→ construction project** (quality of the construction project with all construction elements required in the study for the office);
- **4th Data Drop: accurate information on the level of technical design of the LOD400→** (quality of the technical design, maximum achievable accuracy of building elements in the digital model);
- **5th Data Drop:** the LOD 500 phase is complemented by workshop models of manufacturers and fabricators in the so-called federated model in IFC format for site management.

The recommended levels of information saturation of the model are dictated by the following reasons:

- In the concept and, in many cases, schematic design phases, construction elements are not yet present at all;
- The addressees of this type of modelling granulation requirements are primarily design offices. In the face of the necessity to provide design models in regular iterations (so-called Data Drops), it is unrealistic to change the degree of accuracy of all elements of often complicated models four times during the project. This may be uneconomical for many design offices, especially smaller ones;
- The accuracy level of the LOD 500 can be achieved by combining the updated LOD 400 with supplied workshop models of manufacturers, suppliers and fabricators;
- It is pointless to complicate the management of information about the created asset. The BIM methodology is still complex, you have to get rid of the excess information.

In the amendment to the Building Law [*The Act*], planned for autumn 2020, both the building design and the technical (executive) project are to be introduced as an official project, submitted for approval or documentation of the investment phases in the county building authorities' units. Levels LOD 300 and LOD 400 will be able to be switched during the generation of documentation from the 3D model in a properly conducted design process to present a more schematic representation of the design idea in the building design and more accurate information in the required technical design.

In the meantime, there have been attempts to introduce further granulations, such as LOD 150, LOD 350 or LOD 600 for the as-built documentation phase (As-Built), as well as shortening the names to LOD 1, 2, 3, 4 and 5 (for CityGML, the information recording format used in infrastructure projects), but the main principle of gradation of the investment development phase is still maintained.

Currently, both types of information (LOG and LOI) are modelled by designers in the form of intelligent BIM objects in industry models. The fact that information does not generally have to have the same level of saturation for a given object is a questionable fact of data recording. From buildingSMART's side, it has been proposed to separate these two types of information in order to better manage BIM data and e.g. add alphanumeric information to geometric models from special repositories, based on a classification system (relational tables of type: Attributes or Parameters).

The accompanying benefit of such an additional classification element (in the form of an Attribute/Parameter Table), not found for example in the UK's Uniclass 2015 classification, is the removal of additional levels for

similar object types in favour of saving only their different attributes. In this way, the classification code for the 'family' of elements is one and the same and the difference is made by the attributes, which simplifies the information system. Modern classifications for BIM maintain a fixed number of levels in the hierarchy of object classes in favour of using extensive repositories of their attributes. The following comparative graphics are from the TECHreport TR02 report of the governmental and industrial not-for-profit organization Natspec in Australia in 2019. [53]:

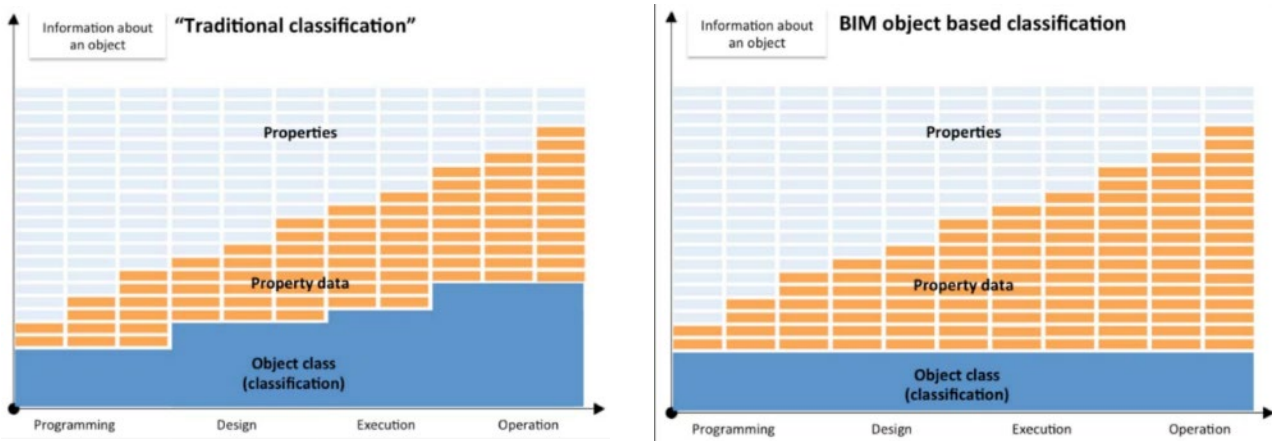


Figure 59: Comparison of the construction classification system with the system based on the reduction of hierarchical levels in the BIM methodology. [53]

The way of managing the splitting of geometric and text information has not yet been fully developed, but there are already applications that provide a complete separation of the two types of data. The planned benefits of such a separation, called Decoupling[160], are significant:

- First, the size of model files will be significantly reduced;
- This will facilitate the early collaboration of many engineers (and the end user or manager of the future asset) on modelling alphanumeric data for their own needs, while designers would work on the visual geometry models;
- The alphanumeric information will be able to be saved in lightweight ASCII files, making it easier to control the revision of subsequent versions;
- The creation programs will focus on their use for modelling object geometry, which will facilitate the reuse of models and their parts in other similar projects in the future as library elements;
- The geometry, cleaned of text ballast and created in BIM applications, will facilitate the definition of IFC format specifications and certification of subsequent versions for these applications;
- Maintaining different levels of information saturation for geometric/opological and textual data will be greatly simplified;
- In accordance with the provisions of the procedures for the provision of asset information in the PN-EN ISO 19650-1 standard, the PIM (Project Information Model) will create a model for AIM (Asset Information Model), cleared of the unnecessary ballast of both types of data generated in the process of asset design and execution. This process will become much easier due to the segregation of information.

THE GENERAL PRINCIPLE UNDERLYING THE DEVELOPMENT OF STANDARDS FOR BIM, NOT JUST CLASSIFICATION, IS TO SIMPLIFY UNNECESSARY COMPLEXITY.

5.8.2.4 Construction classification for Poland

[160]Eng: "separation"

There are no construction classifications tailored to the needs of the BIM methodology in Poland. The existing classification catalogues do not comply with the hierarchical class inheritance and the IFC format standard, which is the basis for all world classifications.

THE POLISH CONSTRUCTION CLASSIFICATION SYSTEM, COMPATIBLE WITH THE HIERARCHICAL METHOD OF CLASS INHERITANCE AND COMPLIANT WITH THE ISO STANDARDS, IS NECESSARY FOR THE IMPLEMENTATION OF THE FULL VERSION OF CONSTRUCTION PROCESSES IN THE BIM METHODOLOGY IN POLAND.

A consequence of the lack of Polish classification is the lack of adequate systems of systematization of works and facilities in official regulations for the construction industry. Currently, the CPV dictionary is included in them, which serves different purposes than the hierarchical BIM classification for all elements in the created investment asset.

Currently, in the so-called Product Room of the Polish branch (the so-called chapter) of buildingSMART International, work is underway to select the best classification option, in accordance with the BIM methodology for the Polish market.

The biggest challenge is that there are currently 3 ISO standards for classification systems (12006-2, 81346-2, 81346-12) and none of them is optimal when they lack a clear definition of hierarchy structure. The choice is therefore not easy. For example, in the course of work on classification for Sweden, two alternative options were proposed in 2016: one based on 12006-2 with three levels of inheritance, and the other based on 81346-2 with two levels [54]. The latter option has been chosen, although the standard 81346-12 for complex construction systems has also been considered. In the face of such doubts, the outcome of the classification works carried out in Poland by bSPL is also not yet determined (as of spring 2020).

5.8.2.5 Training courses

Training in the classification systems should be linked to the basics of the LOD facility information management system, but also to information on the stages of the investment process from programming and conceptualisation to the operation of the asset. Practitioners of Integrated Processes in Construction are therefore recommended as training providers.

5.9 Ecology

Figure 60: Ecology - the fifth element of the matrix in terms of its substance.

Own elaboration

5.9.1 Legal and regulatory ecosystem

- Act of 11 September 2019. Public Procurement Law (**Journal of Laws 2019, item 2019**) , with particular emphasis on the provisions relating to the rules for awarding public contracts, including Article 17(1)(2), i.e. awarding contracts in a manner ensuring the best results of the contract, including social, environmental and economic effects; requirements of the appointing party and description of the subject matter of the contract: Article 101(1)(1)) (taking into account environmental aspects), Article 102 paragraph 1 point 1 (determination of the levels of environmental and climate impact), criteria for evaluation of tenders: Article 242 paragraph 2 points 3 and 4 (qualitative criteria for evaluation of tenders relating to environmental aspects, including energy efficiency of the subject of a procurement and innovation aspects); Article 245 (application of the cost criterion based on life cycle costing covering some or all costs incurred during the life cycle of a product, service or construction works);
- Act of 3 October 2008 on the provision of information on the environment and its protection, public participation in environmental protection and environmental impact assessments (**Journal of Laws 2020, item 283**)[161];
- "National Energy and Climate Plan 2021-2030" (KPEiK) published in version 4.1. on 18 December 2019 by the Ministry of State Assets [55];

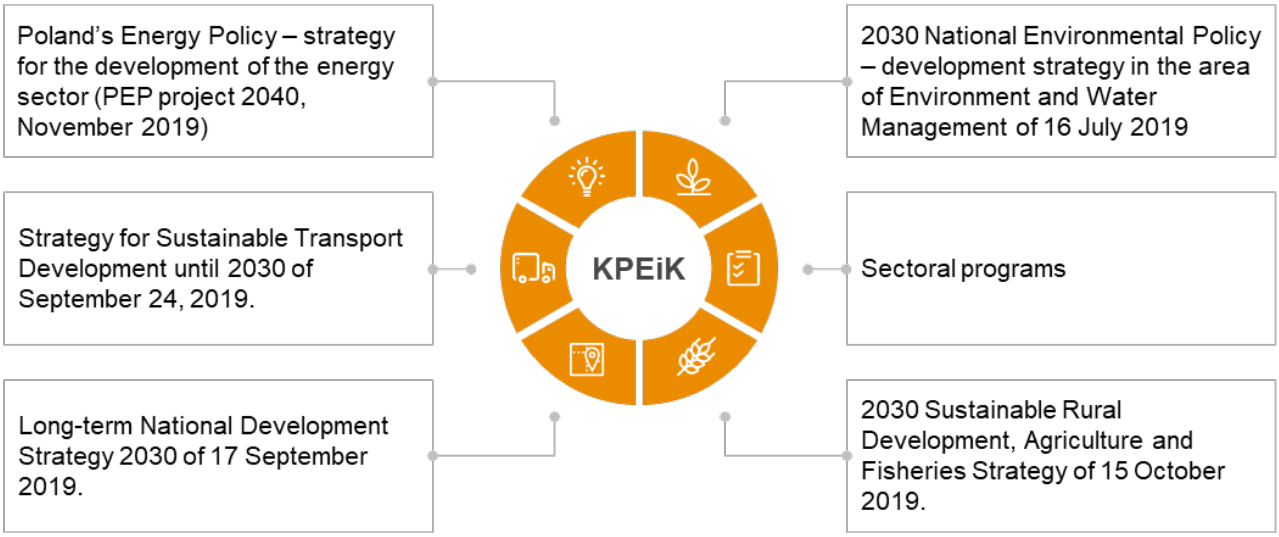


Figure 61: Legislative structure of the NCP programme. [55]

- The NCP was created in response to Regulation (**EU) 2018/1999** of the European Parliament and of the Council of 11 December 2018 on the management of the Energy Union and climate action[162];
- A European Strategic Energy Technology Plan (SET-Plan) published on 22 November 2007 by the Commission of the European Communities (**COM(2007) 723 final**)[163];
- The Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, 28 November 2018, entitled 'A Clean Planet for All. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy' (**COM(2018) 773 final**)[164];
- Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A new EU action plan for a closed-

[161] http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20200000283/U/D20200283Lj.pdf [Access: May 2020] [104]
[162] https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32018R1999&from=EN [Access: May 2020] [105]
[163] https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:52007DC0723&from=EN [Access: May 2020] [106]
[164] https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:52018DC0773&from=EN [Access: May 2020] [107]

loop economy for a cleaner and more competitive Europe, published on 11 March 2020, with an annex (**COM(2020) 98 final**)[165];

- The basis for the above Circular Economy [*Pol. GOZ Plan*] is the Communication from the European Commission to the same addressees called The European Green Deal (**COM(2019) 640 final**) published on 11 December 2019. [56] The European Commission has also launched a strategic environmental roadmap for the whole of Europe;
- Published May 19, 2010. Directive of the European Parliament and of the Council on the energy performance of buildings (EPBD) (**2010/31/EU**)[166];
- Published on 25 October 2012. Directive of the European Parliament and of the Council on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (EED) **2012/27/EU**)[167];
- Standard ISO/DIS 22057 (Enabling use of Environmental Product Declarations (EPD) at construction works level using building information modellingBIM), on the management of the use of EPD (Environmental Product Life Cycle Analysis (LCA) based declarations.) The document is under development;
- MFCA (Material Flow Cost Accounting) standards in the ISO 1400X series of standards: **ISO 14001:2015** (Environmental management systems – Requirements with guidance for use), **ISO 14051:2011**(Environmental management – Material flow cost accounting - General framework) oraz **ISO 14052:2017** (Environmental management – Material flow cost accounting - Guidance for practical implementation in a supply chain) on environmental and energy costs of materials.

5.9.2 Description

In recent years, environmental awareness has been growing exponentially. At present, passive measures, initiated by governmental organisations and NGOs, are not enough; active measures are needed not only to prevent but also to save our environment.

The second reason for adopting a green economy is the healthy need to strive for energy self-sufficiency both for ourselves and for future generations. At the same time, this would mean ensuring energy security in case of possible environmental or man-made disasters.

The environmental system already contains many initiatives, both global and domestic, but all of them are based on concern for the environment in which we live. A significant emphasis is placed on so-called green public procurement, where public authorities can obtain goods, services and construction works with a lower environmental impact during their life cycle compared to goods, services and construction works for the same purpose that would otherwise be procured. As the European Commission points out: Green public procurement can provide public authorities with financial savings - particularly by taking into account the costs of the products or services they procure over their entire life cycle, and not just in terms of purchase price.

For example, buying products with low energy or water consumption can help to significantly reduce utility bills. Reducing the amount of hazardous substances in purchased products can reduce disposal costs. Bodies implementing green public procurement will be better equipped to meet changing environmental challenges as well as to achieve political and binding targets for reducing CO_2 emissions and increasing energy efficiency and other environmental policies.

Green Public Procurement

Public procurement can serve as a tool to shape the production and purchasing preferences of not only public but also private entities. Requiring potential contractors (lead appointed parties) to meet specific environmental requirements will translate into the range of services they offer and, consequently, into an increase in green

[165]https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0007.02/DOC_1&format=PDF[Access: May 2020] [108]
[166]https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32010L0031&from=PL [Access: May 2020] [109]
[167]https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32012L0027&from=PL [Accessed: May 2020] [110]

solutions on the market. Importantly, green procurement places great emphasis on taking into account the entire life cycle of a product, service or construction works, and not only the cost of purchasing them. Such an action in turn affects more economical and effective spending of public funds by the entities which have them at their disposal, which is consistent with the principles contained in the Public Finance Act.

The Energy Efficiency Directive 2012/27/EU is a clear example of instruments to promote green solutions[168]. As pointed out in the preamble to that Directive (recital 15): the public sector is an important driver for market transformation towards more energy-efficient products, buildings and services, and for changing the energy consumption behaviour of citizens and businesses. At the same time, Member States should ensure that public bodies purchase products, services and buildings with very good energy performance (Article 6(1) of the Directive).

Significantly, the Polish Public Procurement Law regulates the possibility of taking into account environmental aspects at different stages of the procedure (within the description of the subject of a procurement or the criteria for evaluating offers). However, the above provisions are regulated in a way that grants the appointing entity the entitlement rather than imposing actual obligaions on it.

The most common non-binding instrument is the Green Public Procurement criteria (so-called GPP criteria). They provide public authorities with requirements, conditions and criteria, as well as contractual provisions which they can directly introduce into the documentation of the procedure. In Poland, GPP criteria have not been published at the national level so far, however, the Public Procurement Office is taking intensive measures to promote European guidelines.

For many European countries, the GPP criteria are the starting point for legislation at national level to help procuring entities to take more environmental aspects into account. The creation of a statutory obligation to take into account certain environmental requirements in public procurement is certainly an effective instrument for the implementation of green public procurement. However, each time the application of rigorous measures requires their appropriate preparation[169].

5.9.2.1 Sustainability

The concept of sustainable development was first extensively discussed in a 1987 UN report. "Our Common Future", known as the Brundtland Report [57] from the name of the head of theWCED (World Commission on Environment and Development). The key to understanding this direction is social responsibility for all development activities in all areas of our lives.

In the following years, several strategic background documents were developed which collated factors influencing sustainable actions. The graphics below present the pyramid of CSR (Corporate Social Responsibility), addressed to big business. The aim is to generate profits with the help of created assets but taking into account also the other two effects of BIM processes: social and environmental. Paradoxically, the global economic crisis, which began in 2007 and lasted for several years, had a great impact on raising awareness of both types of responsibility.

[168]Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, OJ L 315, 14.11.2012, p. 1-56 [110]

[169]This is a consequence of BIM's economic attitude. The highest form of modelled information is the digital twin, which has, like its physical counterpart, a life cycle until disposal. The life cycle is a period from 30 to 50 or even more years, during which all the factors of the living organism on the Earth are active, i.e. apart from economics: ecology and social relations. The Roadmap Matrix of BIM implementation assumes openness to further elements that we do not know today. Ecology is one of the key elements for the future of the world, including the construction industry. Circulation of the physical elements of the model is important both for the life cycle costs of the asset and for the whole built environment, which sooner or later will be digitalized in the form of digital, multidimensional Poland.

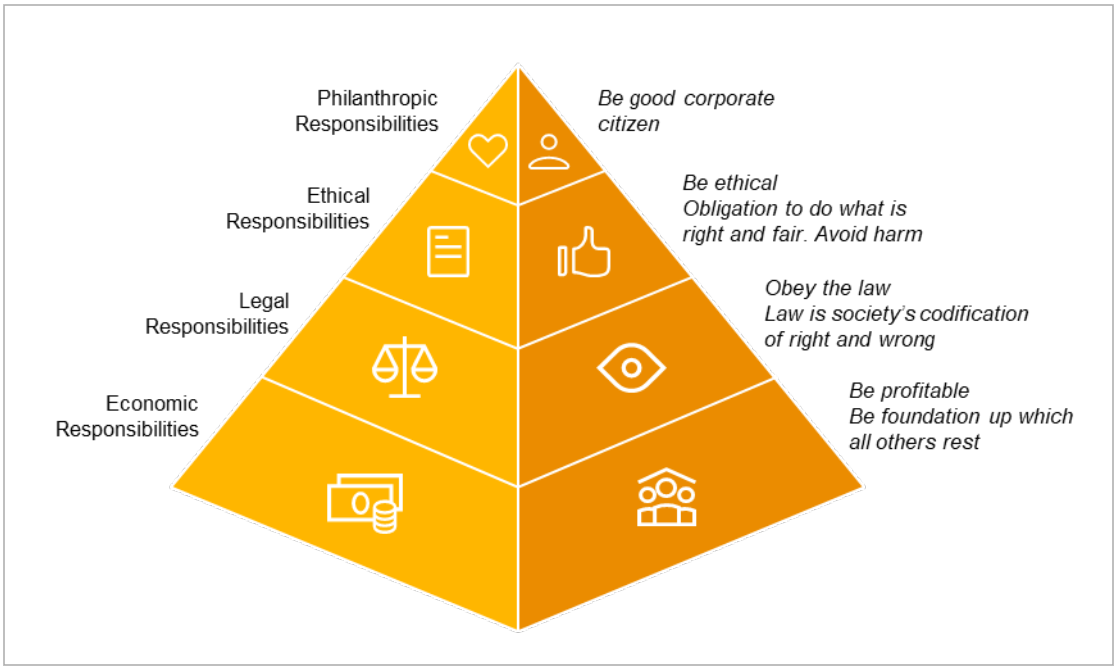


Figure 62: Pyramid of Corporate Social Responsibility CSR.[170]

One of the studies systematizing all sustainability factors was a report of the British Academy "A Complete Definition of Corporate Social Responsibility and Sustainability". (Piercy and Brammer 2012). They have developed a list of sustainability dimensions, which is cited in another study "Enablers for Sustainable Lean Construction in India[171]":

- D1 - Environment;
- D2 - Staff (Employees);
- D3 - Supply Chain;
- D4 - Community;
- D5 - Governance;
- D6 - Quality Issues;
- D7 - Contractual Arrangement - Additional dimension.

On the basis of this matrix, Piercy and Brammer analysed the factors contained in each of the 7 dimensions for diagnosing the effectiveness of Lean implementation and sustainable development for examples of specific entities from different branches of the economy.

There are many sustainable design initiatives, and one of the most advanced is the so-called Cradle-to Cradle Design, based on two variable and interlocking cycles: biological and technological. It is a process of so-called regenerative (i.e. refreshing, renewing and revitalizing own sources of energy and materials) design of products and systems. In this process, the production material is treated as food in an environment of healthy, safe metabolism.

[170] https://research-methodology.net/carrolls-csr-pyramid-and-its-applications-to-small-and-medium-sized-businesses/ [Access: May 2020] [111]
[171] https://pdfs.semanticscholar.org/c4d1/2cfb51e895476180378ad7eb5f284b10032b.pdf [Access: May 2020] [112]

Figure 63: Integration of biological and technological processes "Cradle-2-Cradle"[172]

[172] https://wmprof.com/en/int/nachhaltigkeit_6/cradle_to_cradle_38/cradle_to_cradle.html [Access: May 2020] [113]

5.9.2.2 Circular Economy – (*Pol. GOZ*)

This is a production process that involves minimising the environmental impact of the products used and created. It requires the selection of components and design that will enable the products used in the processes to be reused. The GOZ economy model assumes that the value of products, materials and resources will be maintained in the economy for as long as possible in order to minimise waste generation.

Mentioned in the operative part of the chapter on the EU's GOZ (98 final) (ANNEX to the COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS the New EU action plan for a circular economy for a cleaner and more competitive Europe) [58] has an implementation strategy summarized in a table which clearly defines the legislative basis, value chain, principles and scope of action and procedural steps to achieve a state of environmentally friendly economic processes:

Key activities	**Data**
Framework for sustainable product policies	
Wniosek ustawodawczy dotyczący **inicjatywy w zakresie polityki zrównoważonych produktów**	2021
Wniosek ustawodawczy mający na celu **wzmocnienie pozycji konsumentów w procesie zielonej transformacji**	2020
Środki ustawodawcze i nieustawodawcze ustanawiające nowe „**prawo do naprawy**"	2021
Wniosek ustawodawczy dotyczący uzasadniania **twierdzeń dotyczących ekologiczności**	2020
Obowiązkowe kryteria i cele zielonych zamówień publicznych w przepisach sektorowych i stopniowe wprowadzanie **obowiązkowej sprawozdawczości w zakresie zielonych zamówień publicznych**	od 2021
Przegląd **dyrektywy w sprawie emisji przemysłowych**, w tym włączenie praktyk gospodarki o obiegu zamkniętym do przyszłych dokumentów referencyjnych dotyczących najlepszych dostępnych technik	od 2021
Uruchomienie **prowadzonego przez przemysł systemu sprawozdawczości i certyfikacji opartego na symbiozie przemysłowej**	2022
Key product value chains	
Inicjatywa dotycząca urządzeń elektronicznych o zamkniętym cyklu życia, rozwiązanie w zakresie uniwersalnych ładowarek oraz **systemy nagradzania za zwrot starych urządzeń**	2020/2021
Przegląd dyrektywy w sprawie w sprawie **ograniczenia stosowania niektórych niebezpiecznych substancji w sprzęcie elektrycznym i elektronicznym** oraz wytyczne objaśniające jej powiązania z rozporządzeniem REACH i wymogami dotyczącymi ekoprojektu	2021
Wniosek w sprawie nowych **ram regulacyjnych dotyczących baterii**	2020
Przegląd przepisów dotyczących **pojazdów wycofanych z eksploatacji**	2021
Przegląd przepisów dotyczących właściwego przetwarzania **olejów odpadowych**	2022
Przegląd w celu **zaostrzenia zasadniczych wymagań dotyczących opakowań, ograniczenia (nadmiernego) stosowania opakowań i redukcji odpadów opakowaniowych**	2021
Obowiązkowe wymogi dotyczące **zawartości tworzyw sztucznych pochodzących z recyklingu** oraz **środków ograniczania ilości odpadów tworzyw sztucznych** w przypadku kluczowych produktów, takich jak opakowania, materiały budowlane i	2021/2022

Figure 64: Circular economy Implementation strategy part 1. [58]

pojazdy	
Ograniczenia dotyczące **celowo dodawanych mikrodrobin plastiku** oraz środki w zakresie **niezamierzonego uwalniania mikrodrobin plastiku**	2021
Ramy polityki dotyczące **biopochodnych tworzyw sztucznych i biodegradowalnych lub kompostowalnych tworzyw sztucznych**	2021
Strategia UE dla sektora włókienniczego	2021
Strategia na rzecz zrównoważonego środowiska zbudowanego	2021
Inicjatywa na rzecz **zastępowania jednorazowych opakowań, naczyń stołowych i sztućców produktami wielokrotnego użytku w usługach gastronomicznych**	2021
Less waste, more value	
Cele w zakresie redukcji ilości odpadów dla określonych strumieni i inne środki dotyczące **zapobiegania powstawaniu odpadów**	2022
Ogólnounijny **ujednolicony model selektywnej zbiórki odpadów i etykietowania** mający ułatwić selektywną zbiórkę	2022
Metody śledzenia i minimalizowania obecności substancji potencjalnie niebezpiecznych w materiałach pochodzących z recyklingu i wytworzonych z nich wyrobach	2021
Zharmonizowane systemy informacji w zakresie obecności substancji potencjalnie niebezpiecznych	2021
Określenie zakresu przyszłych **ogólnounijnych kryteriów dotyczących zniesienia statusu odpadu oraz produktów ubocznych**	2021
Przegląd przepisów dotyczących **przemieszczania odpadów**	2021
Adapting the circular economy to the needs of people, regions and cities	
Wspieranie przejścia na gospodarkę o obiegu zamkniętym za pomocą: **programu na rzecz umiejętności**, przyszłego **planu działania na rzecz gospodarki społecznej**, **paktu na rzecz umiejętności** oraz **Europejskiego Funduszu Społecznego Plus**	od 2020
Wspieranie przejścia na gospodarkę o obiegu zamkniętym za pomocą: **funduszy polityki spójności, mechanizmu sprawiedliwej transformacji i inicjatyw miejskich**	od 2020
Cross-cutting activities e	
Poprawa metod pomiaru, modelowania i narzędzi politycznych służących do osiągnięcia **synergii między gospodarką o obiegu zamkniętym a łagodzeniem zmiany klimatu i adaptacją do niej** na szczeblu unijnym i krajowym	od 2020
Ramy regulacyjne w zakresie **certyfikacji usuwania dwutlenku węgla**	2023
Uwzględnienie celów gospodarki o obiegu zamkniętym w przeglądzie wytycznych	2021

Figure 65: Circular economy Implementation strategy part 2. [58]

dotyczących **pomocy państwa w dziedzinie środowiska i energii**	
Uwzględnianie celów gospodarki o obiegu zamkniętym w kontekście przepisów dotyczących **sprawozdawczości niefinansowej** oraz inicjatyw w zakresie **zrównoważonego ładu korporacyjnego i rachunkowości środowiskowej**	2020/2021
Leadership in global activities	
Pozycja lidera w dążeniu do osiągnięcia **globalnego porozumienia w sprawie tworzyw sztucznych**	od 2020
Zaproponowanie **światowego sojuszu na rzecz gospodarki o obiegu zamkniętym** oraz zapoczątkowanie dyskusji na temat **międzynarodowego porozumienia w sprawie gospodarowania zasobami naturalnymi**	od 2021
Uwzględnianie celów gospodarki o obiegu zamkniętym w **umowach o wolnym handlu**, w innych procesach i porozumieniach na **poziomie dwustronnym, regionalnym i wielostronnym** oraz w **instrumentach finansowania polityki zewnętrznej UE**	od 2020
Monitoring progress	
Aktualizacja **ram monitorowania gospodarki o obiegu zamkniętym** w celu uwzględnienia nowych priorytetów politycznych oraz opracowania kolejnych **wskaźników dotyczących wykorzystania zasobów**, w tym **śladu konsumpcyjnego i materiałowego**	2021

Figure 66: Circural economy implementation strategy part 3.. [58]

In Poland, the Ministry of Development is the[173]body responsible for coordinating the implementation of the GOZ strategy. On 10 September 2019 The Council of Ministers adopted a resolution on the adoption of the "Roadmap for Transformation towards a Circular Economy", thus giving the green light for the GOZ initiative in our country.

Earlier (in 2017), the Ministry of the Environment initiated a pilot programme called "Circular Economy in the Community", as amended in 2019.[174]The pilot program was financed by the National Fund for Environmental Protection and Water Management. By 2020, three communes were to participate in it: Łukowica (Małopolskie Voivodeship), Tuczno (Zachodniopomorskie Voivodeship) and Wieluń (Łódzkie Voivodeship), but the program was later extended by two more communes: Krasnobród (Lubelskie Voivodeship) and Sokoły (Podlaskie Voivodeship).

The EU legal tool supporting the transition to a circular economy is the so-called Waste Package (adopted by the EU on 22 May 2018), i.e. the amendment of directives on waste management[175].

5.9.2.3 Low-carbon emission and energy efficiency

This is one of the most recently discussed points in European environmental strategies, as it relates to the energy foundations of national regional economies.

The EU has already published a number of plans and directives in this direction (see overview at the beginning of the chapter) and their overall objective is to reduce the carbon footprint by 2050.

Currently, Poland has been granted a special status in this matter, but it does not fit in with the common agreement of the other EU countries, so it should be expected to be corrected in the future. This correction, however, will require substitute solutions in order not to hamper the economy, so it is impossible to predict the date of changes in the course.

Another programme is the EU Energy Efficiency Programme for the results of the construction industry, i.e. the assets built (Directives 2010/31/EU and 2012/27/EU - see section 5.9.1). Analyses of the energy economy have been carried out for Polish cubature facilities (because they are mainly concerned with them) for a long time and these changes have become permanent in Polish building regulations. First of all, these are the

[173]https://www.gov.pl/web/klimat/goz [Access: May 2020]
[174]https://nfosigw.gov.pl/oferta-finansowania/srodki-krajowe/programy-priorytetowe/gospodarka-o-obiegu-zamknietym/ [Access: May 2020] [114]
[175]https://portalkomunalny.pl/unia-przyjela-pakiet-odpadowy-goz-coraz-blizej-375093/ [Access: May 2020] [115]

"Technical Conditions", which include the EU provisions on the energy efficiency of buildings in a several-stage programme of changes to the target state in 2021)[176].

Relevant EU bodies monitor the progress of the energy efficiency strategy through reports such as "Improving resource and energy efficiency", published in January 2019 by the European Construction Industry Observatory [59]. This study summarises the results of the application of national rules that have been developed on the basis of the EU and resembles the existing directives to sustain the development.

5.9.2.4 PED (Positive Energy Districts)

The PEDs were launched in the EU's SET-Plan (see point 5.9.1) and are ultimately urban environments with zero primary energy demand and zero carbon emissions with the additional objective of overproduction for use in local and central networks. This requires close coordination of building performance, the lifestyles of building users, the characteristics of local energy networks, mobility rules and ICT functionalities[177].

This project is based on the activity of one of the 10 fields of engagement of the SET Plan, called "Smart Cities and Communities" (No 3.2 of the plan). This activity aims to create 100 PED sustainable urbanisation areas in the EU JPI countries by 2025. The scope of activities is the planning, implementation and replication of the created asset to subsequent locations.

This also has an impact on urban planning, which is part of the competence of the construction industry. Projects are already being developed on this basis, such as a building proposal for 200,000 users, meeting all PED requirements and equipped with high-tech systems. This is a concept of the so-called vertical city of the Luca Curci Architects team (Bari, Italy) called THE LINK:

Figure 67: Visualisation of THE LINK, a vertical city designed by the Italian team Luca Curci Architects.[178]

Similar concepts, although without an ecological context and with the characteristic intransigence of modernism, already existed in the past, e.g. Swiss architect Le Corbusier in 1925 proposed a complex of skyscrapers for 3 million inhabitants for the reconstruction of the centre of Paris (the so-called Plan Voisin - graphics below). This shows that the development is based on well-known foundations.

[176] http://www.a-ronet.pl/a_prawo/ustawy/2019_1065.pdf [Access: May 2020] [116]
[177] https://cityxchange.eu/knowledge-base/ped/ [Access: May 2020] [117]
[178] https://aasarchitecture.com/2020/04/the-link-by-luca-curci-architects.html/ [Access: May 2020] [118]

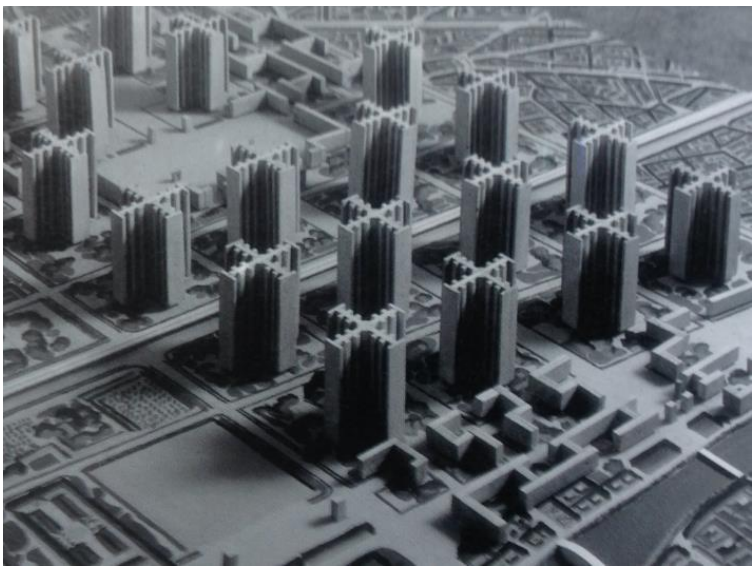


Figure 68: Model Plan Voisin for the centre of Paris - Le Corbusier.[179]

The Urban Europe JPI (Joint Programming Initiative) project was formed in 2010 on the basis of the EU SET Plan (Strategic Energy Technology) (see introduction to the chapter) with funding from Horizon 2020 as one of the EU instruments called Joint Programming, launched by the EU in 2008. The initiative aims to improve the quality of urban life in Europe[180].

There are 20 countries participating in JPI Urban Europe, 14 of which are full members (Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Italy, Latvia, the Netherlands, Norway, Slovenia, Sweden and the United Kingdom) and 6 countries have observer status (Estonia, Poland, Portugal, Romania, Spain and Turkey). Several further countries participate in the EU JPI on a project basis. The initiative has a portfolio of more than 70 projects in the field of ecology and environmental protection with a total funding of more than €100 million and cooperation on ecology with countries outside Europe. One of the current projects is the initiative of these PEDs.

In November 2019 another project was launched, funded by the European Commission from Horizon 2020, called ATELIER[181], which is an organisation of two cities: Amsterdam and Bilbao. This initiative also plans to create and replicate PEDs in these two locations. Another 6 (Bratislava, Budapest, Copenhagen, Cracow, Matosinhos and Riga) have joined as partners and are planning to replicate PEDs in their own locations.

5.9.2.5 Bottom-up actions for sustainable development

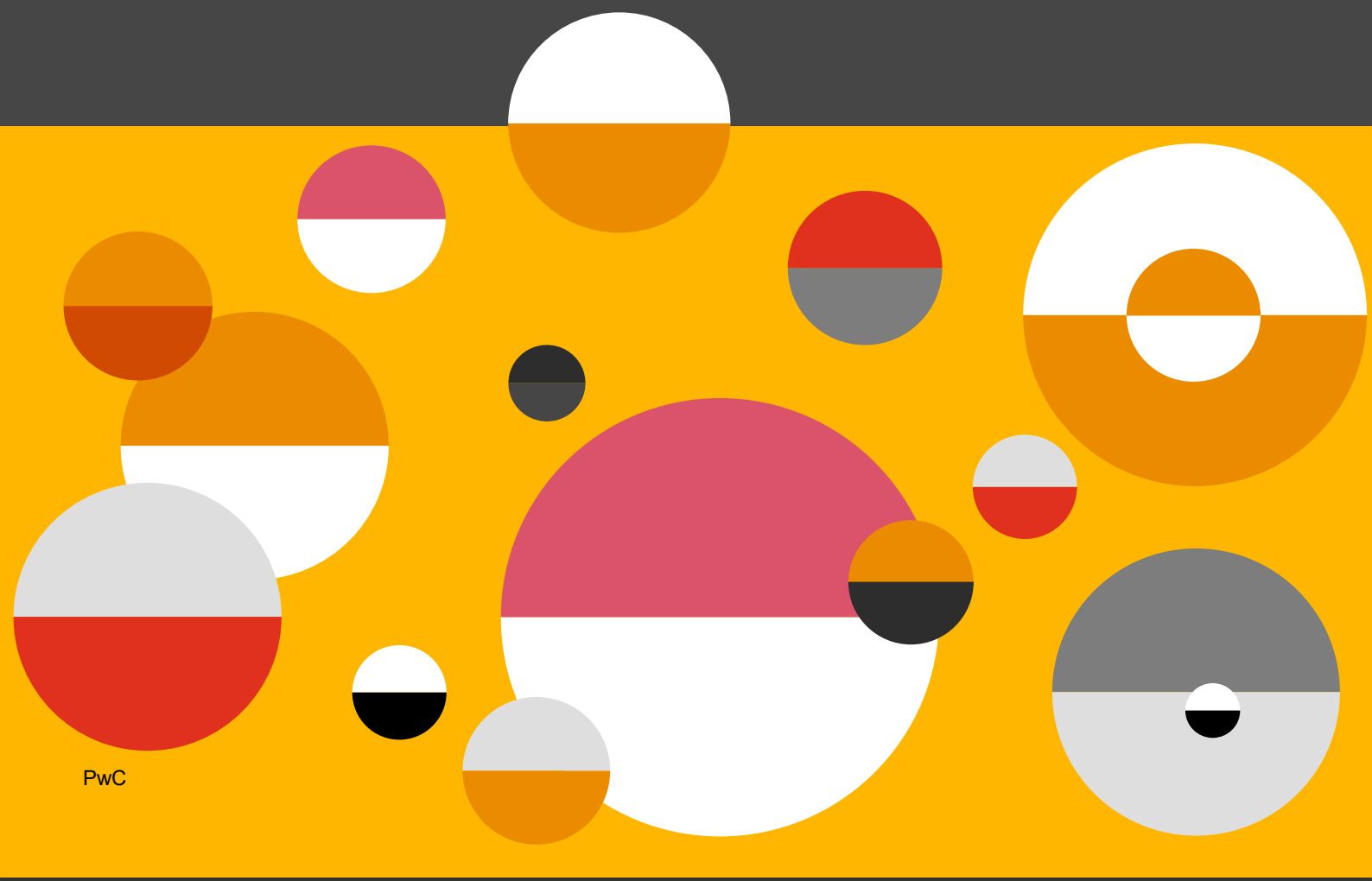
In response to top-down regulations, responsible private and social actors themselves initiate measures to protect the environment, achieve energy efficiency and social responsibility for human activities. The list of these initiatives is growing year on year and it will be impossible to list them all, as the list is dynamic, and no one should be left out here.

5.9.2.6 Training courses

There are Internet portals in Poland dealing with ecological phenomena and movements. They offer a wide range of thematic literature and often also training. Also, the representations of engineers, associated in regional and national chambers of commerce, offer training for their members in ecological issues. Similar initiatives have been implemented by public entities, such as the National Fund for Environmental Protection and Water Management or the Ministry of Climate [182].

[179] https://en.wikipedia.org/wiki/Plan_Voisin [Access: May 2020]
[180] https://jpi-urbaneurope.eu/app/uploads/2019/09/Leaflet-JPI-UE-4P.pdf [Access: May 2020] [119]
[181] https://smartcity-atelier.eu [Access: May 2020]
[182] https://www.gov.pl/web/klimat/szkolenia-dla-wnioskodawcow [Access: May 2020] [120]

VI. Matrix nodes – introductory remarks



6 Matrix nodes – introductory remarks

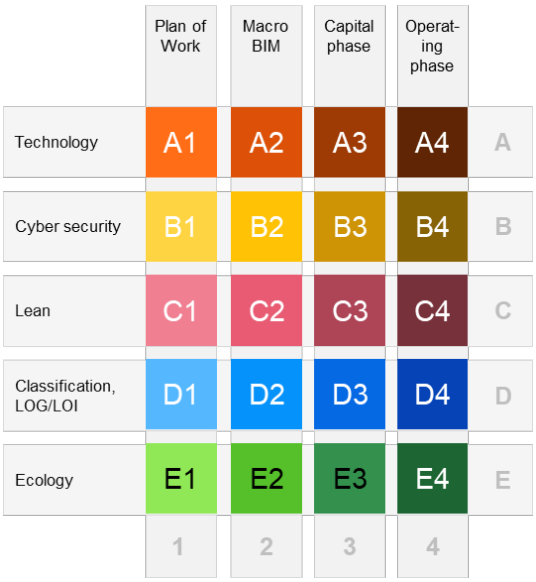


Figure 69: Summary of matrix nodes.

Own elaboration

The orthogonal, non-linear structure of the individual elements of the matrix creates points of intersection at the nodes common to the intersecting elements. These are the points where two domains combine their specifications for maximum interoperability.

The typology of matrix nodes is an open system, just like the matrix itself. The aim of this document is not a detailed description of all elements of the entire road to implement BIM in Poland, but rather creating an environment that will facilitate the implementation of BIM in our country. Nodes in their current form should be treated as homogeneous packages that will both find their places on the timeline and are recommended to treat them as task units to be performed. If the content of the nodes is corrected, the time axis presented in point 8 should also be corrected.

In the next chapter, solutions will be proposed to fill the nodes with tasks, their schedule, recommended responsibilities and the necessary financial outlays, as far as it was possible to estimate them.

The most important thing, however, is the knowledge of what place particular elements of the system have in the entire Roadmap and the integrated processes in construction. Nodes, in addition to the usual color palette, also have specified field signatures (as on a chessboard) to allow the presentation of the document in any organisational environment and user, and to better illustrate their distribution on the timeline.

In the 3D view (point 8) node blocks represent the amount of work to be done and the time that needs be spent in order for a given node to reach maturity in the BIM system.

Tasks in individual nodes do not have a chronology of implementation, but for order and for the application of their results in pilot projects, they should be read in the chronology of the columns (i.e. stages of the integrated process in BIM), so tasks e.g. C1 should precede tasks in C2, then follow the tasks C3 and further C4.

For the stage of implementation of individual node components (next chapter) the following graphics are adopted:

	The implementation of a component of the node has not yet been initiated
	The implementation of a component of the node is in progress
	The implementation of a component of the node has been achieved

Figure 70: Graphic description of task tables in nodes.

Own elaboration

For the assessment of financial outlays and activation of other resources, it has been adopted, where possible, to divide them into three levels using bold print:

Black print marks low expenditure.

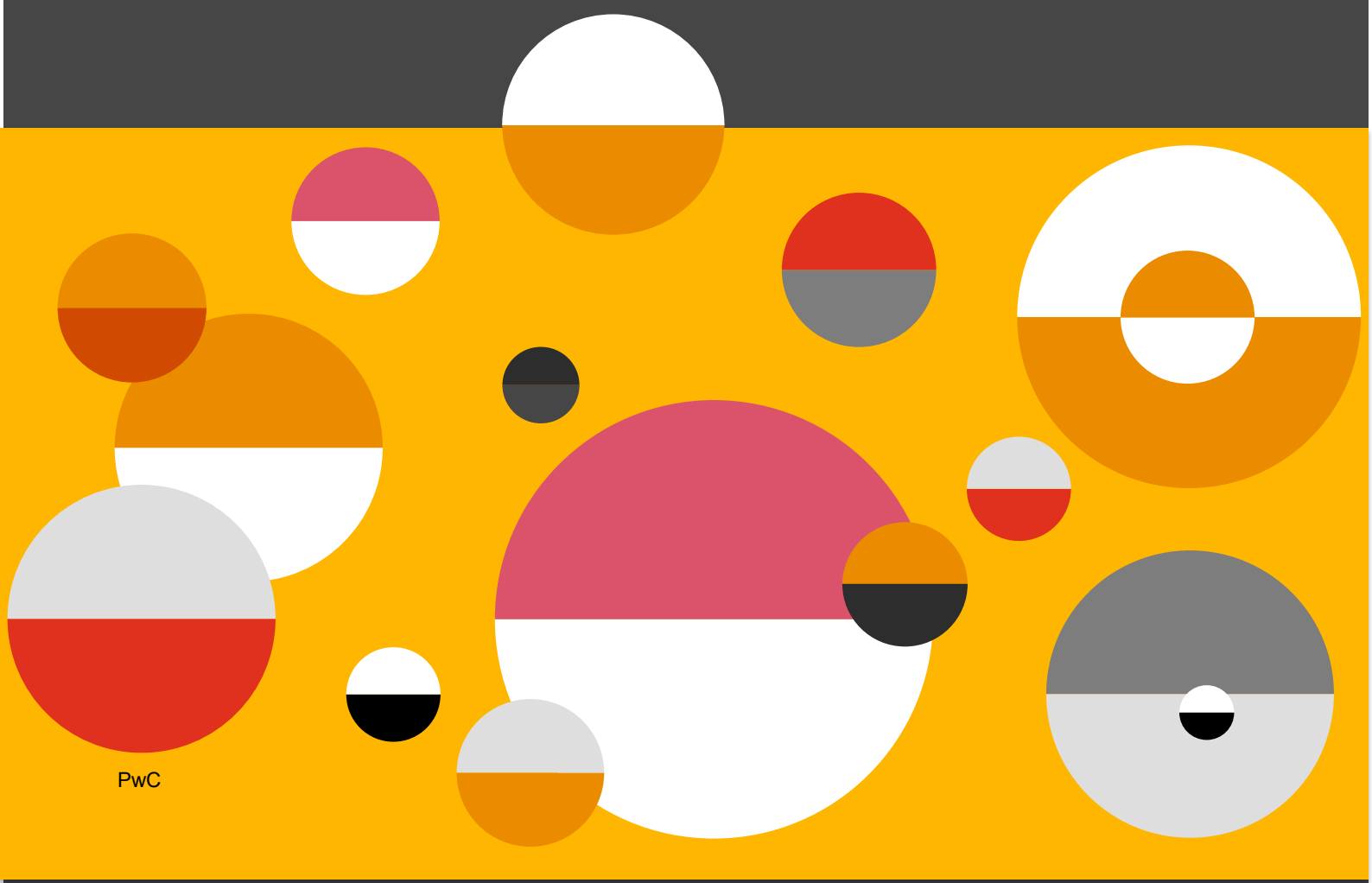
Orange print marks medium expenditure.

Red print marks high expenditure.

However, it should be noted that these are estimates that do not take into account the size or financial capacity of the entity responsible for the performance of the task.

IN ORDER TO UPDATE THE ROADMAP, REGULAR REVIEW OF THE STATUS OF MATRIX NODES ELEMENTS IN THE 2-3-YEAR MODE SHOULD BE PERFORMED. IT IS RECOMMENDED TO ANALYSE ALL NODES FOR THE FULL IMAGE OF BIM IMPLEMENTATION AT THE TIME OF UPDATING THE REPORT.

VII. Matrix nodes in detail



7 Matrix nodes in detail

7.1 Node A1 (Technology in the Work Plan)

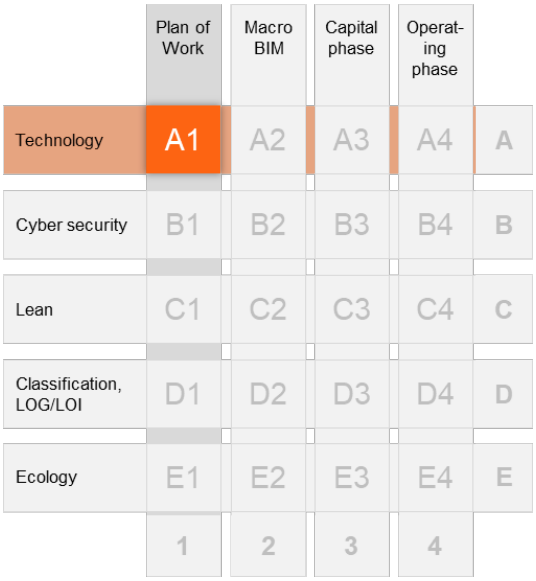


Figure 71: Node A1.

Own elaboration

Table 8. Package A1

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Adoption of BIM standards for Poland (PN-EN ISO 19650 series), previously published and new that have been announced. Regular monitoring of the new announced solutions in this area, in order to prepare for implementation by the construction market	Familiarization with the documents explaining the functionality of the standards, then admission to practice	Public institutions and other construction market stakeholders	**Low rank of costs** – purchase and familiarization with normative documents, practical training; Task teams for implementation of standardisation. Workloads depending on the scale of actions; Internal and external trainings
2	A media campaign promoting the BIM Roadmap and the process of implementing BIM in Poland	Top-down propagation should give impetus to bottom-up activities	Minister competent for economy as a leader	**Medium rank of costs** – costs of media exposure; Implementation of tasks by the BIM propagation media unit or a team of people responsible for this operation, delegated from the existing operational unit for promotion tasks. Workloads depending on the scale of actions
3	Adoption of the open	Mental shift to a	Public institutions and	**Medium rank of costs** – changes to

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	formats, Open BIM principles, interoperability and simple diagrams for exchange of information in BIM	different organisation of work	other construction market stakeholders	the procedures currently functioning in the field of communication and information exchange Internal and external trainings; Information campaigns; Decision makers, Change Champions. Workloads depending on the scale of actions
4	Structuring the CAD environment in construction investments in accordance with PN-EN ISO 19650-1: 2019	Mental shift to a different organisation of work	Design office	**Medium rank of costs** – changes in usual procedures; Change Champions, technologists. Workloads depending on the scale of actions (implementation of standard information structures); Internal and external trainings
5	Establishment of a Steering Committee for BIM implementation		Minister competent for economy as a leader in consultation with key ministries	**Low rank of costs** – establishment of a working group; Delegation of coordinators of activities in institutions to the organizational structure of the Committee, ensuring the consistency of BIM implementation work. Average monthly commitment depending on the intensity of works; Determination of the organisation's physical seat
6	Adoption of strategic assumptions from this study and related documents for the Roadmap of BIM development in Poland as they emerge	Mental switch to the use of BIM methodology for construction investments based on top-down example with bottom-up acceptance	Minister competent for economy as an implementation leader in cooperation with relevant departments within the Steering Committee for the Implementation of BIM. Approval by the Chancellery of the Prime Minister	**Low rank of costs** – declaration of central level entitities on the active promotion of the BIM methodology; Steering Committee; Specialists of the institution delegated to those works. Workloads depending on the scale of actions
7	Update of the Roadmap in a 2-3-year cycle	It is recommended to introduce guidelines on how to collect information on the progress of BIM implementation	Steering Committee as an author or commissioning the studies	**Medium rank of costs** – analysis of the progress of the implementation process and report; Steering Committee; Specialists, employees of the institution delegated to those works or external specialists employed for the purposes of carrying out the above works. Workloads depending on the scale of actions
8	Providing active support for BIM by engineering professional chambers	The first step is the BIM recommendation document in the construction industry developed by the PIIB PIIB (Polish Chamber of Engineers) in 2019	Chambers representing engineers in the construction industry	**Low rank of costs** – a top-down declaration of support for the BIM methodology for professional groups; Creation of BIM units in the organization of professional chambers. Workloads depending on the scale of actions
9	Launching a project (public procurement) aimed at implementing	A multi-module IT platform promoting the BIM methodology and	Minister competent for economy	**High rank of costs** – commissioning a public procurement for the implementation and maintenance of

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	an IT platform supporting the application of BIM, in accordance with the specification developed under this project [183]	supporting the purchase of public investments in this methodology		an IT platform; On the leader's side, resources needed to prepare and conduct the tender procedure to evaluate offers (including the substantive scope) as well as the project delivery supervision; Specialists, employees of the institution delegated to those works or external specialists employed for the purposes of carrying out the above works
10	Initiation of legislative changes aimed at implementing BIM into the Polish public procurement legal system	The first steps towards establishing the BIM obligation are: 1. Develop a draft procurement policy with the desired direction for the contracting authorities' activities understood as the use of BIM and tools to enforce and promote the use of BIM, 2. Change the non-price criteria for evaluation of bids in proceedings to incorporate 20% for the BIM methodology, while 60% for the price criterion. The above change will apply to investments carried out in BIM	Minister competent for economy as a process leader	**Low rank of costs** – decision to start the legislative process at the level of the minister responsible for the economy; Steering Committee; On the leader's side, resources needed to prepare and carry out the above-mentioned legislative changes
11	Developing a program for full-time studies including BIM	Lack of BIM qualifications among the academic staff	Minister competent for economy, minister competent for science and higher education, academic staff	**Medium rank of costs** – changes in the study program, change management; Mobilization of specialists from educational entities dealing with program changes in higher education by responsible entities; Steering Committee; The implementation of tasks by work coordinators within educational units involving workload, depending on the scale of activities. It has been assumed that the scale of activities will require part-time work; Internal and external consultations
12	Developing a curriculum for secondary technical schools including BIM	Lack of qualified teaching staff, recommendation of coordination with the plan for higher education	Minister competent for education	**Medium rank of costs** – changes in the curriculum, change management; Steering Committee; The implementation of tasks by work coordinators within educational units involving workload, depending on the scale of activities. It has been assumed that the scale of activities

[183]The IT platform referred to in the document will be devoted to a separate study of this project

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
				will require part-time work; Internal and external consultations
13	Increasing the budget for research and development (R&D) in the field of construction	The funds should be allocated to works aimed at increasing innovation in construction	Minister competent for economy as a process initiating leader	**High rank of costs** – updating the national budget and / or in the area of distribution of Polish EU funds, updating the budgets of individual ministries
14	Introducing the obligation to use BIM for public investments in Poland for the value of investments from EUR 10 million	Extension of the BIM requirement from task A.1.10	Minister competent for the economy, Steering Committee	**Medium rank of costs** – declaration with all economic consequences; Steering Committee; On the leader's side, resources needed to prepare and carry out those legislative changes
15	Legislative changes to be considered at the Public Procurement Law level in the scope of enabling the contracting authority to cancel the procedure at the stage of initial offers	A change necessary to use the MacroBIM model. It concerns the cancellation of the procedure if the value of the initial offers significantly exceeds the estimated cost of the contract	Minister competent for economy as a process leader	**Low rank of costs** – decision to start the legislative process at the level of the minister responsible for the economy; Steering Committee; On the leader's side, resources needed to prepare and carry out the above-mentioned legislative changes

7.2 Node A2 (Technology in MacroBIM)

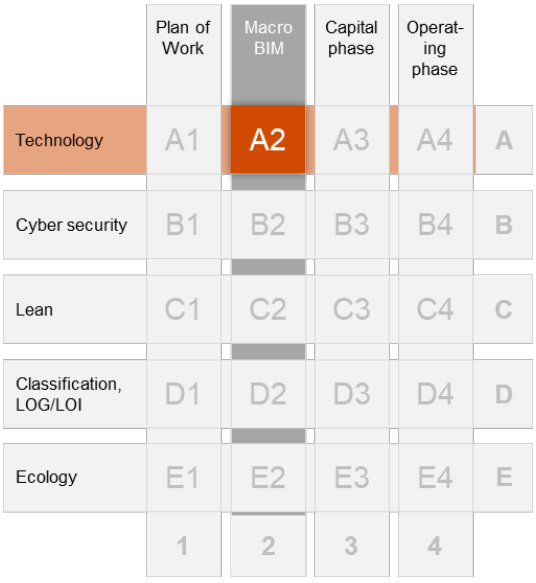


Figure 72: Node A2.

Own elaboration

Table 9. Package A2

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Adoption of the PN-EN ISO 19650-1: 2019 standard for the organization structure of the investment team	Change in the organization of construction processes	Public institutions and other construction market stakeholders	**Low rank of costs** – task teams for the implementation of standardization in construction; Internal and external trainings.
2	Adoption of a phased division of work following the British Digital Plan of Work (DPoW) model with the introduction of an additional investment verification phase - MacroBIM	Change in the organization of procurement in construction	Public institutions and other construction market stakeholders	**Medium rank of costs** – changes to the adopted procedures and formal tender procedures; Mobilization of specialists in the organization of construction processes by responsible entities
3	Introduction and application of investment conceptual programming principles: block models max. LOD 100, models of grouped functions max. LOD 200	Only blocks and grouped functions, without any additional elements, a change in the design phasing (change of current methods of calculating investments costs)	Public institutions and other construction market stakeholders, especially design offices	**Low rank of costs** – the need to take action in the area of change management to support the actual application of the principles of conceptual modeling; Specialists in the preparation and implementation of construction processes; Internal and external trainings
4	Introduction and application of benchmark valuation principles for concept design models, based on index price catalogs in order to develop a project Target Cost proposal	Bulletin of benchmark costs could be helpful, e.g. annually updated "WKI Sekocenbud", change of current methods of calculating investments costs	Public institutions and other construction market stakeholders, especially construction cost estimators	**Low rank of costs** – adopting the principles of creating valuations; Calculation specialists in the construction processes; Internal and external trainings; Purchase and implementation of calculation programs based on models by responsible entities
5	Training courses on the creation of benchmark calculations of project concept design	It is assumed that the duration of the training should not exceed 6 teaching hours and should be partially workshop-based. The training will be dedicated to construction cost estimators and personnel responsible for planning and managing the cost of the investment	Specialists for training in the field of indicator (benchmark) costing	**Medium rank of costs** – cost of organisation of trainings; Selection of training organisers in the tender for calculations of models by decision makers at construction contractors; Determining the physical location of training
6	Develop a multilateral, incentive Joint Venture contracts for the integration of all investment participants with the BIM methodology	Available contract templates for use in international publications Matching contracts to the Polish market in cooperation with professional representative offices	Minister competent for economy in cooperation with the Public Procurement Office, Law firms, professional group insurers	**Medium rank of costs** – development of a new type of BIM construction contracts for the Polish market; Steering Committee; On the side of the leader, resources needed to prepare and carry out the above works (building contracts' specialists)
7	Use of multilateral, incentive Joint Venture contracts for the		Public procurement other stakeholders in the construction market	**Medium rank of costs** – readiness to use this type od contract, the need to develop mutual trust among

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	integration of all investment participants with the BIM methodology			participants of the investment process Trainings; Information campaigns (in the competence of the media unit / BIM promotion team). Workloads depending on the scale of actions

7.3 Node A3 (Technology in Delivery Phase)

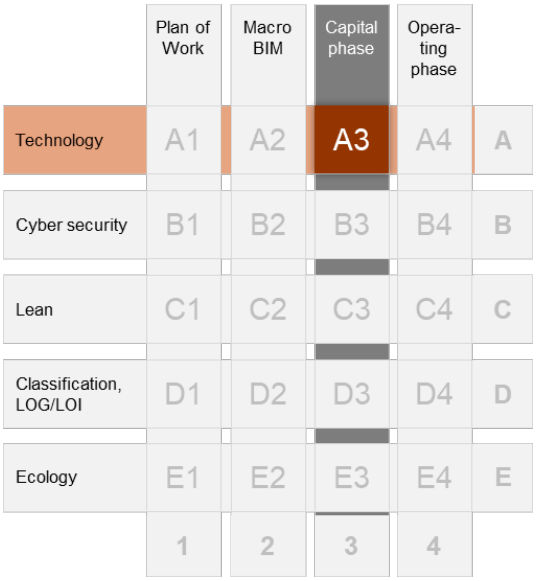


Figure 73: Node A3.

Own elaboration

Table 10. Package A3

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Adoption and use of open information exchange formats in BIM (IFC, BCF, CityGML) in investments, in accordance with ISO 16739-1: 2018	Available in exports from all BIM applications certified by buildingSMART International	Public institutions and other construction market stakeholders	**Low rank of costs** – acceptance and actual application of standard rules in practice; Task teams for the implementation of standardization in construction; Internal and external trainings
2	Adoption for each investment in BIM of the digital information processing environment (CDE), in accordance with PN-EN ISO 19650-2:2019	This is already common for investments with BIM elements. CDE functionalities are not yet optimally used, and they are established for the needs of a given investment	Public institutions and other construction market stakeholders	**Low rank of costs** – relatively low costs of renting CDE platforms; Change Champions, teams for implementing new technologies in construction; Internal and external trainings
3	Development of a complete digital,	Delivery format as a complex, multi-industry	Design office	**Medium rank of costs** – from approx. 4,000 to 15,000 PLN / year /

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	multidimensional model of information about the created asset - Project Information Model (PIM)	IFC model		job position; Change Champions, teams for implementing new technologies in construction; Internal and external trainings
4	Develop templates and use pre-contract and contract documents in BIM investments: BIM protocol, pre-contract BEP, BEP (BIM Implementation Plan)	There are patterns available, they will also be developed in a separate document within this project	Minister competent for economy as a leader (publication of templates under this project) Public institutions and other construction market stakeholders	**Low rank of costs** – acceptance and actual application of standard rules in practice; IT BIM platform - to popularize BIM management templates; Internal and external trainings
5	Acceptance for use of the types of required information about the created asset: EIR, OIR, PIR, AIR and plans for creating MIDP and TIDP information, in accordance with PN-EN ISO 19650-2: 2019	These are top-down activities that require close coordination with bottom-up activities in the form of delivery schedules (Last Planner® System from the Lean tool palette)	Public institutions and other construction market stakeholders	**Medium rank of costs** – changes in the organization of proceeding in construction investment; Change Champions, teams for implementing new technologies and standardisation in construction; Internal and external trainings
6	Organisation of several-day, initiating BIM workshops before the start of each investment carried out in this methodology	BIM workshops should be integrated with Lean workshops; It is assumed that the workshops should last about 3 days	Minister competent for economy in cooperation with the Public Procurement Office for public investments; Participants of each investment in the BIM methodology	**Medium rank of costs** – training costs; Selection of BIM and Lean training organizers by entities responsible for the individual investments; Determining the physical location of trainings

7.4 Node A4 (Technology in the Operational Phase)

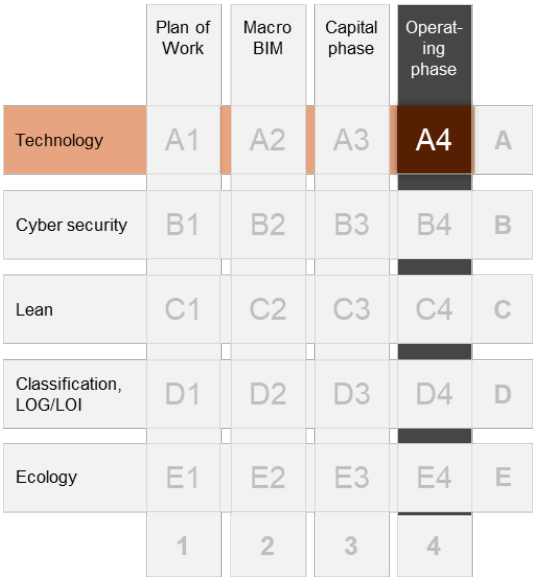


Figure 74: Node A4.

Own elaboration

Table 11. Package A4

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Adopting the COBie data format as the primary information management format in the asset maintenence - operational phase		Public institutions and other construction market stakeholders	**Low rank of costs** – saving models in IFC format for export to COBie; Change Champions, specialists in asset creation, delivery and management (in order to implement and apply standard information exchange technologies); Internal and external trainings
2	Development of a complete digital, multidimensional model of information about the created asset - Asset Information Model (AIM)	This is a version of the PIM model, tailored to meet the asset management needs after commissioning	Industry designers in given investments, construction managers, subcontractors	**Medium rank of costs** – updating design models to the actual required as-built status; Change Champions, specialists in asset creation, delivery and management (in order to implement and use standard information exchange technologies); Internal and external trainings
3	Adoption and use of a complete digital, multidimensional model of information about the created asset - Asset Information Model (AIM)		Property managers and technical conservators	**Medium rank of costs** – updating design models to the actual technology level; Change Champions, specialists in asset creation, delivery and management (in order to implement and use standard information exchange technologies); Internal and external trainings; Obtaining the asset management software using AIM models in open formats by the responsible subjects
4	Development of the Polish version of the PN-EN ISO 19650-3 standard and the ISO 5500X series for the structure of asset management processes	As a next step – translate the full text of the standards into Polish	Polish Committee for Standardisation (pol. PKN) (relevant Technical Committee)	**Low rank of costs** – saving the standards in the Polish normative standard; Works within the relevant PKN Technical Committee
5	Adoption of the PN-EN ISO 19650-3 standard and the ISO 5500X series	Change to integrated asset management processes	The entire FM market (facility management) - Property managers	**Low rank of costs** –adopting standard rules of conduct; Change Champions, asset management specialists (in order to apply BIM standards); External trainings; Information campaigns (in the competence of the media unit / BIM promotion team)
6	Creation of digital duplicates - Digital Twins (DT) from information contained in AIM models for electronic, remote management	The first Digital Twins trials already exist, but they do not yet contain the required level of data Is is assumed the Digital Twins costs will decrease over time	Public procurers as implementation leaders. Industry designers or external entities	**High rank of costs** – update of federated IFC models to the Digital Twins standard; Change Champions, Specialists in asset creation, delivery and management (in order to implement and use standard information exchange technologies); Internal and external trainings

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
7	Assessment of the asset life-cycle cost and presenting these calculations according to the provisions in the Regulation		The entire FM market (facility management) Property managers Branch designers	**High to medium rank of costs** – costs of implementing the act for emerging assets; Change Champions, specialists in asset creation, delivery and management (in order to implement and use standard information exchange technologies); Internal and external trainings.
8	Development of a digitization strategy for the physical area of Poland for a period of min. until 2030 (underground and ground infrastructure, construction, water reservoirs, geospatial)	Available EU funds from the pool for strategic recommendations for 2021-2027	The minister competent for digitisation in cooperation with the minister competent for obtaining EU funds	**Medium rank of costs** – if EU funding to develop a strategy will be obtained; Steering Committee; Specialists in obtaining EU funds, digitalization specialists, employees of the institution delegated to those works or external specialists employed for the purposes of carrying out the above works.
9	Creating a digital model of Poland (Digital Twin) based on the strategy of digitization		Public institutions and business entities on the construction market	**High rank of costs** – significant costs of modelling multidimensional Poland; Change Champions, Specialists in asset creation, delivery and management (in order to implement and use standard information exchange technologies); Internal and external trainings; Related activities - information campaign. Implementation of actions by the BIM propagation media unit or a team of people responsible for this scope delegated from the existing organizational unit for promotion. Workloads depending on the scale of actions.

7.5 Node B1 (Cybersecurity in the Work Plan)

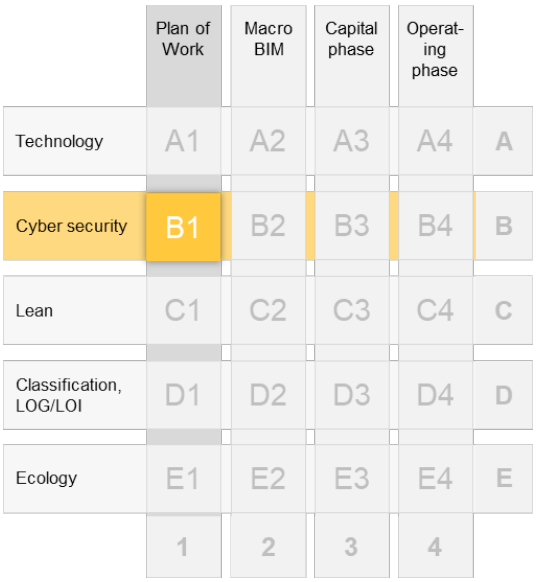


Figure 75: Node B1.

Own elaboration

Table 12. Package B

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	The use of optimal digital security (Digital Safeguards) in accessing Internet network services	Security can be made in-house by IT staff of a given entity	Public institutions and business entities on the construction market	**Low rank of costs** – costs of standard securities; Mobilization of market entities for the implementation and use of digital security; Delegation of internal IT specialists to digital security tasks
2	Amendment to the Act on the national cyber security system (Journal of Laws 2018, Item 1560) to use secure methods of processing information on the network		Minister competent for digitisation	**Low rank of costs** – costs of amending the act; Steering Committee; Specialists, employees of the institution delegated to those works (legislative changes regarding digital security) or external specialists employed for the purposes of carrying out the above works.

7.6 Node B2 (Cybersecurity in MacroBIM)

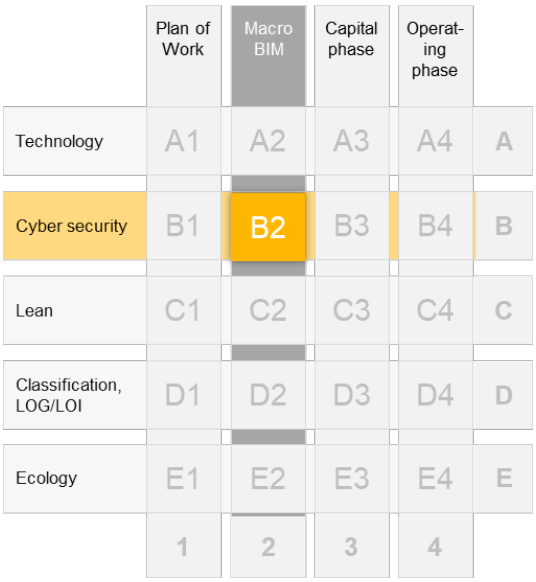


Figure 76: Node B2.

Own elaboration

Table 13. Package B2

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	The latest deadline during the investment for checking and updating digital security in business entities and institutions, in the form of IT services	The service may require creating a security system from scratch	Public institutions and business entities on the construction market	**High rank of costs** – updating or creating a new cybersecurity system; Mobilization of market entities in construction in order to implement and apply digital security tasks by responsible subjects; On the leader's side resources for preparation and conducting of the tender procedures and offers' review on hiring of IT specialists for the cybersecurity actions and maintenance of the security systems in public subjects

7.7 Node B3 (Cybersecurity in the Delivery Phase)

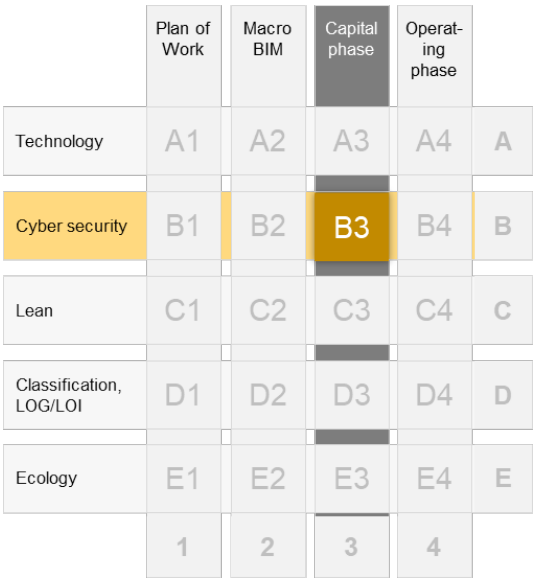


Figure 77: Node B3.

Own elaboration

Table 14. Package B3

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Establishing access roles to CDE - a digital investment support information environment		Participants of each investment in the BIM methodology	**Low rank of costs** – the establishment of access roles is within the scope of every CDE platform; Mobilization of specialists in the creation, delivery of assets, and asset management by responsible subjects in order to apply new technologies.
2	Developing a PN-EN ISO 19650-5 standard for the security of information service during the investment period (including national annexes)		PKN (relevant Technical Committee)	**Medium rank of costs** Only security updates from the B2 node are assumed; Works within the relevant PKN Technical Committee
3	Adoption of the PN-EN ISO 19650-5 standard for the security of information service during the investment procedure (including national annexes)	The publication of the standard, announced at the end of 2020, is required	Public institutions and other construction market stakeholders	**Medium rank of costs** Only security updates from the B2 node are assumed; Task teams for the implementation of standardization in construction; Internal and external trainings.

7.8 Node B4 (Cybersecurity in the Operational Phase)

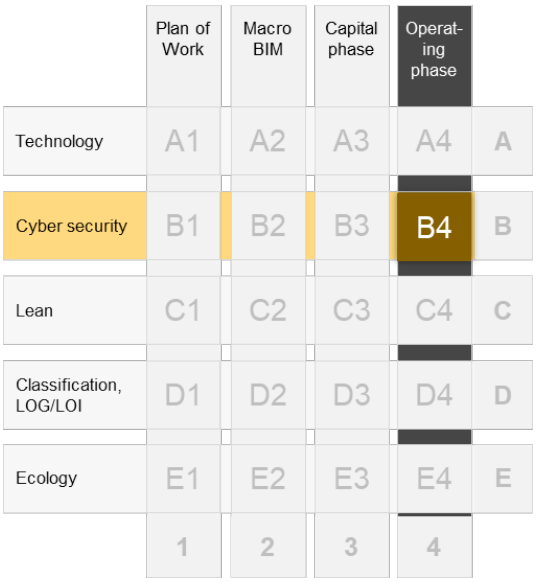


Figure 78: Node B4.

Own elaboration

Table 15. Package B4

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Widespread adoption of DLT (Distributed Ledger Technology) for various forms of services in the construction industry and asset management	Already introduced by some market entities of other industries These actors could serve as examples of good practice to support the adoption of technology by other entities	Public institutions and other economic market stakeholders	**Medium to high rank of costs** – costs of technological changes in IT; Change Champions, Specialists for creation and delivery of assets (in order to implement and use new technologies); Internal and external trainings.

7.9 Node C1 (Lean in the Work Plan)

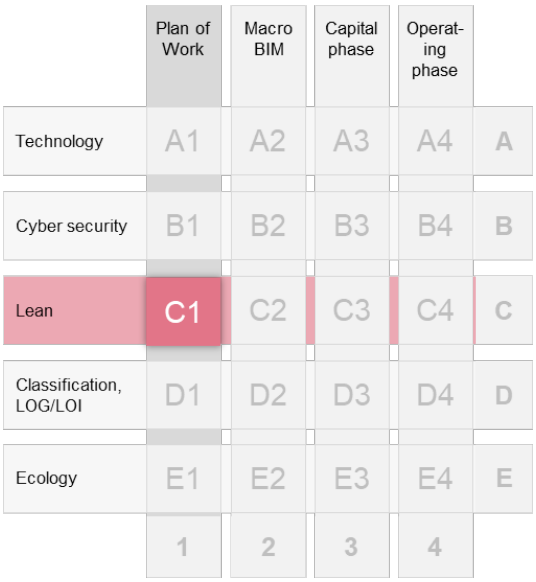


Figure 79: Node C1.

Own elaboration

Table 16. Package C1

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Introduction and application of the Plan - Do - Check – Act (PDCA) method for process management		Public institutions and other construction market stakeholders	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, Specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
2	Introduction and application of the A3 one-page strategy tool for the goal setting process in organisation		Public institutions and other construction market stakeholders	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
3	Development of a strategy for the implementation and monitoring of pilot projects using BIM	The first pilot project in infrastructure was launched by the Ministry of Infrastructure in 2020	Minister competent for economy and Steering Committee	**Medium rank of costs** – selecting and preparing investments for pilot projects. Steering Committee; Specialists in creation, strategy implementation, and process monitoring (in order to develop a strategy for launching and conducting pilot projects, proper selection of projects) - employees of the

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
				institution delegated to the above-mentioned works or external specialists employed to carry out those works.

7.10 Node C2 (Lean in MacroBIM)

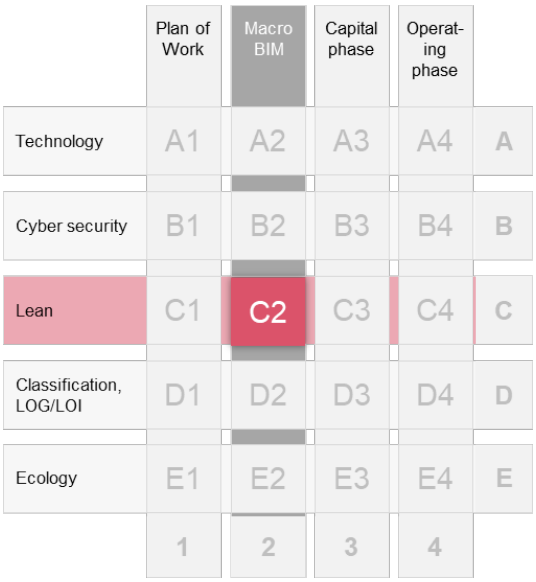


Figure 80: Node C2.

Own elaboration

Table 17. Package C2

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Introduction and application of holistic project information management methods (System thinking and other methods)		Public institutions and other construction market stakeholders	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
2	Introduction and use of the POP matrix tool (Product - Organisation - Process) for the evaluation of goals and expectations regarding the planned investment	A tool for the appointing party to identify the objectives of the undertaking	Public institutions and other construction market stakeholders	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
3	Introduction and use of the visual Value Stream	A tool for the lead appointed party to verify	Public institutions and other construction	**Low rank of costs** – assimilating Lean principles, change of the way of

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	Mapping (VSM) tool for creating and correcting investment process diagrams in construction	the legitimacy of the steps in the investment process	market stakeholders	work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
4	Introduction and use of the Selection Tool according to the "Choosing by Advantages" (CbA) method for making decisions on the use of alternative options in the process of economic evaluation of investments		Public institutions and other construction market stakeholders	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
5	Developing and applying the rules for creating Target Cost proposals based on conceptual models of blocks and functions	Including an additional phase in public procurement	Participants of each investment in the BIM methodology	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.

7.11 Node C3 (Lean in the Delivery Phase)

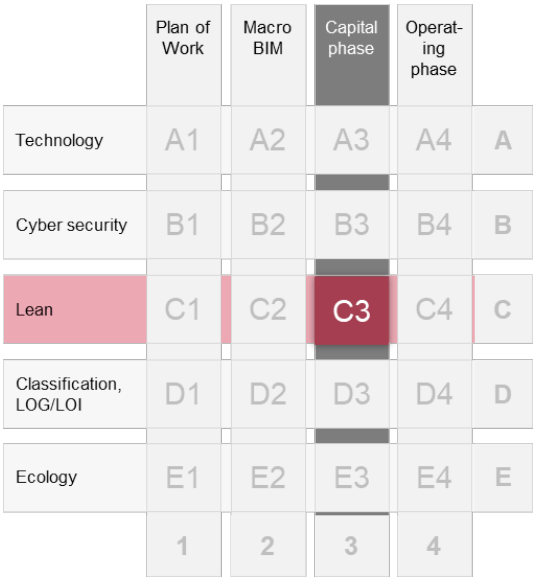


Figure 81: Node C3.

Own elaboration

Table 18. Package C3

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Creating a decision-making Core Group, the entire Integrated Team and task teams - process organization	According to formulas from the PN-EN ISO 19650-1: 2019 standard and Lean practices	Representatives of all parties to the investment	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
2	The introduction and application of the method of joint resolution of current investment tasks in one room (Big Room) with full technological equipment	The Big Room should be prepared by the appointing party near the construction site	Participants of each investment in the BIM methodology	**Low rank of costs** – room costs for the entire period of the project; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Internal and external trainings.
3	Introduction and use of Lean visual tools in everyday construction production practice (creation of the asset): visual labeling, 5S, Agile / Scrum, 5x Why? and the Fishbone Diagram	Executive team training, together with the participation of the appointing party	Lean Expert / Integrated Team as the contractor of the asset creation and delivery process	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) - employees of individual units delegated to the above-mentioned works or external specialists employed for the purposes of those works; Internal and external trainings.

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
4	Introduction and application of the Last Planner System® for the project scheduling as bottom-up equivalent of the Master Information Delivery Plan (MIDP) and Task Information Delivery Plan (TIDP) in the Big Room	Executive team training, together with the participation of the appointing party	Lean expert / contractor of the asset creation and delivery process	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) - employees of individual units delegated to the above-mentioned works or external specialists employed for the purposes of those works; Internal and external trainings.
5	Introducing the function of Value Stream Mapping manager for analysing and adjusting the workflow in the investment process	The expert is on the part of the contractor to optimize the asset delivery process	Lean expert / appointing party and lead appointed party of the asset creation and delivery process	**Medium rank of costs** – costs of a Value Stream Mapping expert; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) - employees of individual units delegated to the above-mentioned works or external specialists employed for the purposes of those works; Internal and external trainings.
6	Organisation of practical training in Lean methodology for the entire Integrated Team (all key participants)	The training program should be integrated with the initiating workshops for BIM	Lean expert / appointing party and Lead appointed party of the asset creation and delivery process	**Medium rank of costs** – costs of Lean training; Providers of training (BIM and Lean) employed by the appointing parties; Designation of the physical location for trainings (Big Room)
7	The introduction and application of an elimination tool for 8 sources of losses in investment processes - the principles of “muda” reduction	Briefing of the delivery team will be necessary	Lean expert / performer of the asset delivery process	**Low rank of costs** – assimilating Lean principles, change of the way of work; Change Champions, Specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) - employees of individual units delegated to the above-mentioned works or external specialists employed for the purposes of those works; Internal and external trainings.
8	Introduction of large-size prefabrication systems for automation of the building processes	Lean Manufacturing (lean fabrication)	Lead appointed parties in investment processes in BIM methodology	**Medium rank of costs** – factory production costs instead of at the construction site, modernisation and utilization of improved product lines; Change Champions, specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) - employees of individual units delegated to the above-mentioned

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
				works or external specialists employed for the purposes of those works. Internal and external trainings.

7.12 Node C4 (Lean in the operational phase)

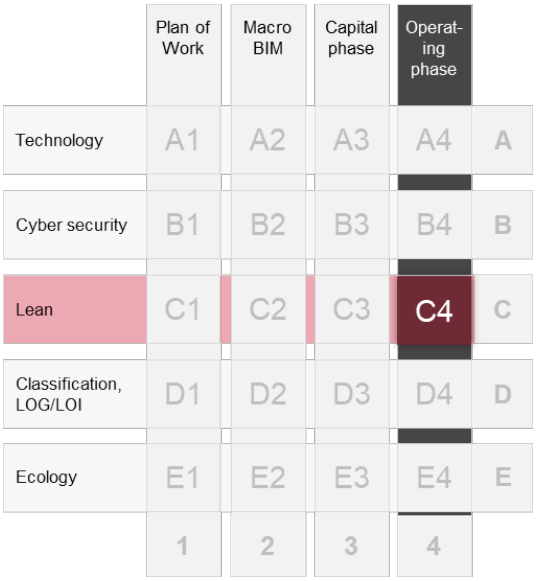


Figure 82: Node C4.

Own elaboration

Table 19. Package C4

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Application of the principles of elimination of 8 types of losses (“muda”) in asset management processes		Operators of public facilities as leaders. The entire FM (Facility Management) market, e.g. RICS Polska	**Low rank of costs** – adoption of Lean principles, change of the way of work; Change Champions, Specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) - employees of individual units delegated to the above-mentioned works or external specialists employed for the purposes of those works; Internal and external trainings.

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
2	Applying Lean Six Sigma principles: a reduced list of solutions with increased control and elimination of losses	It is a combination of Six Sigma with Lean	Operators of public facilities as leaders. The entire FM market (facility management) - Real estate management	**Low rank of costs** – adoption of Lean principles, change of the way of work; Change Champions, Specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) - employees of individual units delegated to the above-mentioned works or external specialists employed for the purposes of those works; Internal and external trainings.

7.13 Node D1 (Classifications in the Work Plan)

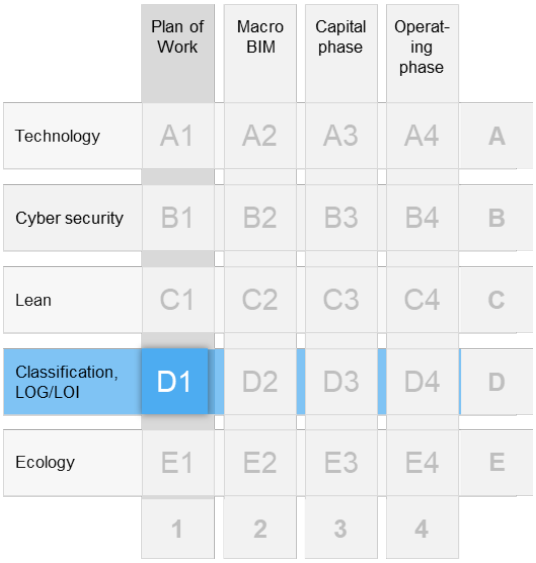


Figure 83: Node D1.

Own elaboration

Table 20. Package D1

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Creating a construction classification system for Poland adequate for BIM processes	Currently under development by the Polish branch of buildingSMART International	buildingSMART International - Polish branch (chapter)	**High rank of costs** – costs of creating the Polish version of the classification; Mobilization of members of the Polish buildingSMART chapter in order to create and/or propose the implementation of the Polish classification
2	Including the new construction classification in all	Replacement of CPV (Common Procurement Vocabulary) with new	Minister competent for economy as a leader	**Medium rank of costs** – costs of amendments to selected regulations

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	legislative documents for carrying out construction processes in Poland	classification codes		(point 6.8.1); Steering Committee; On the leader's side resources will be needed to prepare and carry out the legislative changes
3	Implementation and use of classification on the Polish market	Adaptation to new classification codes	Public institutions and all stakeholders of the construction industry	**High rank of costs** – costs of implementing the solution on the Polish construction market; Change Champions, Specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction); Related activities - information campaign. Implementation of tasks by the BIM propagation media unit or a team of people responsible for this area delegated from the existing organizational unit for promotion. Workloads depending on the scale of actions
4	Publication of Polish versions of standards for product information structuring (ISO 23386: 2020 and announced ISO 23387) for smooth integration of building classification elements with product codes for the Supply Chain		PKN (relevant Technical Committee)	**Low rank of costs** – development of the Polish version of the standard; Works within the relevant PKN Technical Committee
5	Implementation of Polish versions of ISO 23386: 2020 and announced ISO 23387 standards		Public institutions and all stakeholders of the construction industry	**Low rank of costs** – adopting standard rules; Change Champions, Specialists in creation, delivery, and management of assets (in order to implement and apply new methods in production processes in construction) Related activities - information campaign. Implementation of tasks by the BIM propagation media unit or a team responsible for this area delegated from the existing organizational unit for promotion. Workloads depending on the scale of actions

7.14 Node D2 (Classifications in MacroBIM)

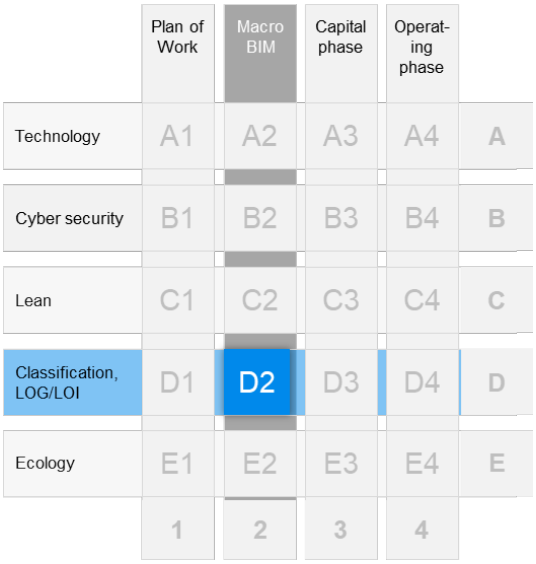


Figure 84: Node D2.

Own elaboration

Table 21. Package D2

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Use of the LOD information level up to LOD 100 for blocks and LOD 200 for functions in the MacroBIM phase		Participants of each investment in the BIM methodology	**Low rank of costs** – adopting new rules; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings
2	Introduction and application of information modelling for elements at LOD levels corresponding to investment phases	Adequate training is currently offered on the market	Participants of each investment in the BIM methodology	**Low rank of costs** – adopting new rules; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings
3	Introduction and application of the linkage of classification system with the LOD information saturation levels, structuring this information for compliance with the IFC hierarchy for all investment phases	Only possible after creating the classification	Participants of each investment in the BIM methodology	**Low rank of costs** – adopting new rules; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings
4	Integrating BIM with Geographic Information System (GIS)	Required for the operation of a uniform classification system	buildingSMART International	**Low rank of costs** – external study; Change Champions, Specialists in the implementation of new technologies and methods in

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
				construction; Internal and external trainings

7.15 Node D3 (Classifications in the Delivery Phase)

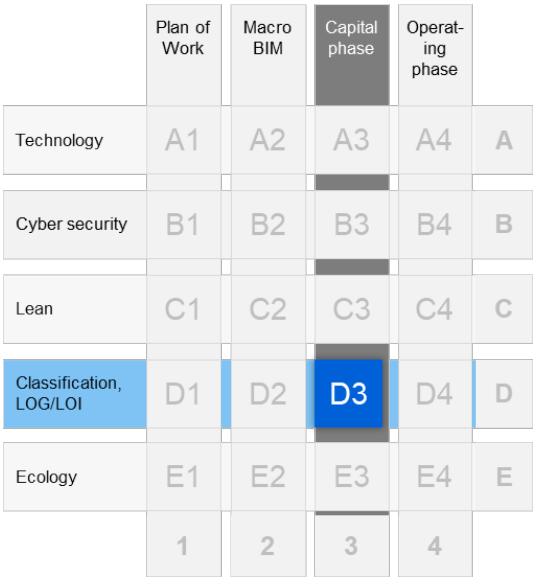


Figure 85: Node D3.

Own elaboration

Table 22. Package D3

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Limiting the number of LOD levels for the component elements of the models to three, in accordance with the provisions of the amendment to the Building Law: schematic (LOD 200), construction (LOD 300), technical (LOD 400)	The LOD 100 level (and possibly LOD 200 for zones) applies for conceptual blocks and functional layouts in the investment programming phase (MacroBIM)	Participants of each investment in the BIM methodology	**Low rank of costs** – adopting new rules; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings
2	The use of sensors embedded in a physical asset to remotely handle information		Public and private investors	**Medium rank of costs** –costs of systems of automation with sensors; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings; Implementation and applying of sensor technologies in the built assets
3	Introduction by designers of	Mapping of classification systems	Participants of each investment in the BIM	**Medium rank of costs** – costs of entering classification codes for

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	appropriate classification codes for future Polish classification into elements of industry models for IFC format exports	to model elements is currently available in several applications	methodology	buildings in models Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings
4	Mapping in IFC class design models to CityGML until IFC 5 certification is launched and the format is widely used	Essential in BIM models for mixed infrastructure and cubature projects	Participants of cubature and infrastructure investment in BIM methodology	**Medium rank of costs** – costs of mapping building identifiers to infrastructure; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings
5	Mapping of IFC GUIDs to bSDD matrix identifiers for the preparation of digital integration of construction products and materials with computer models (PIM / AIM / Digital Twins)	a. The condition for the task to occur is to create a classification (refer node D1.1) b. The task is currently being carried out by buildingSMART Poland in cooperation with buildingSMART International and classifying entities	buildingSMART, participants of every investment in the BIM methodology	**High rank of costs** – costs of mapping classification codes in design models; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings.
6	GTINs mapping of GS1 identification system (or other option) to bSDD identifiers for entering product and material codes into PIM/AIM/Digital Twins computer models	a. The condition for the task to occur is to create a classification (task1 in node D1) b. The task is currently being carried out by buildingSMART Poland in cooperation with buildingSMART International and classifying entities	buildingSMART, Participants of each investment in the BIM methodology	**High rank of costs** – costs of mapping classification codes with identification codes in design models; Change Champions, specialists in the implementation of new technologies and methods in construction; Internal and external trainings

7.16 Node D4 (Classifications in the Operational Phase)

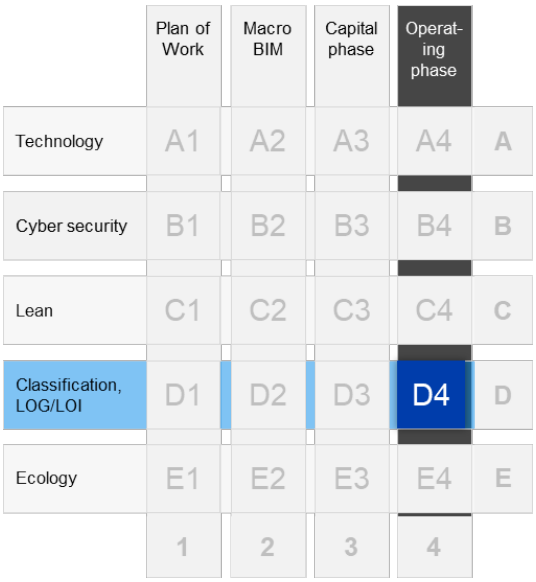


Figure 86: Node D4.

Own elaboration

Table 23. Package D4

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Introduction and application of management of combinations of classification codes with product and material identifiers for the operational needs of the assets		The entire FM market (facility management) Property managers	**Medium rank of costs** – ID mapping costs; Change Champions, Specialists in the implementation of new technologies and methods in construction; Internal and external trainings
2	Introduction and use of remote (via Internet of Things - IoT and 5G) management of combination of classification codes with product and material identifiers in Digital Twins facilities	After the entry into force of the 5G network	The entire FM market (facility management) Property managers	**High rank of costs** – the costs of creating and managing Twins; Change Champions, specialists in the implementation of new technologies and methods in construction; Internal and external trainings.
3	Introduction and use of remote information handling in the unstructured form of Big Data, flowing from sensors embedded in physical assets through their digital duplicates (Digital Twin)		The entire FM market (facility management) Property managers	**High rank of costs** – the costs of creating and managing Twins; Change Champions, specialists in the implementation of new technologies and methods in construction; Internal and external trainings.

7.17 Node E1 (Ecology in the Work Plan)

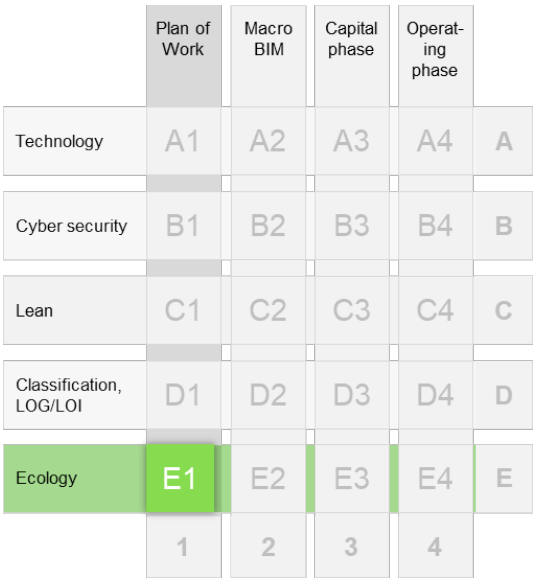


Figure 87: Node E1.

Own elaboration

Table 24. Package E1

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Implementation of the European Green Deal provisions by Poland		Minister competent for climate matters	**High rank of costs** – acceptance costs are relatively low, but the economic adjustment costs are very high; Change Champions, Specialists in the application of ecological methods in economic processes – task teams delegated the above works or external specialists employed for the purposes of carrying out these works; Related activities - communications campaign. Implementation of tasks by the BIM promotion media unit or a team responsible for this area delegated from the existing unit for promotion. Workloads depending on the scale of actions
2	Poland's accession to the COM(2018) 773 final on a clean economy with a reduced carbon footprint by 2050.	An economic and political decision	Minister competent for climate matters	**High rank of costs** – acceptance costs are relatively low, but the economic adjustment costs are very high; Change Champions, specialists in the application of ecological methods in economic processes – task teams delegated to the above works or external specialists employed for the purposes of carrying out these works; Related activities - communications campaign. Implementation of tasks

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
[redacted]				by the BIM promotion media unit or a team responsible for this area delegated from the existing unit for promotion. Workloads depending on the scale of actions

7.18 Node E2 (Ecology in MacroBIM)

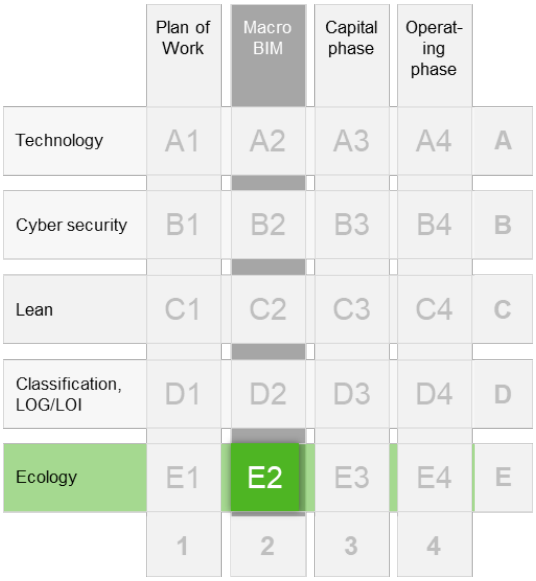


Figure 88: Node E2.

Own elaboration

Table 25. Package E2

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Applying the principles of sustainable design in the preparation of environmentally friendly investment concept designs (circular economy, use of rainwater, energy self-sufficiency, passive construction, etc.)		Project delivery teams preparing MacroBIM proposals	**Low rank of costs** – adopting new rules; Change Champions, Specialists in the application of ecological methods in construction processes - employees delegated to the above works or external specialists employed for the purposes of carrying out those works; Internal and external trainings.

7.19 Node E3 (Ecology in the Delivery Phase)

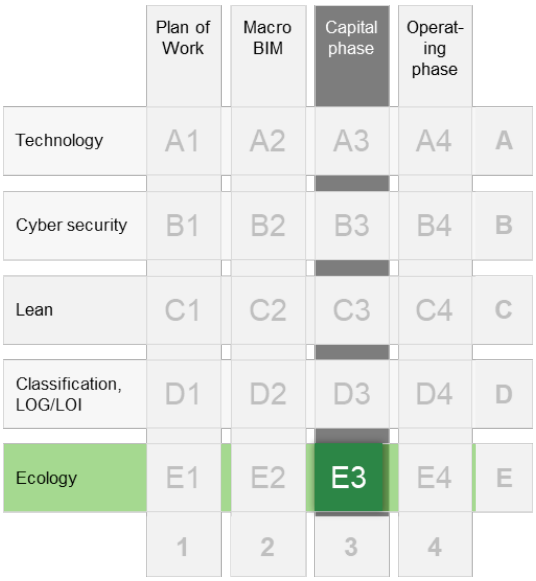


Figure 89: Node E3.

Own elaboration

Table 26. Package E3

Status, order	Package components Notes	Responsible entities	Necessary costs and assets
1	Introduction and application of energy certification standards in Poland (eg. LEED, BREEAM, DGNB, Passivhaus)	Public institutions and all stakeholders of the construction market	**Medium rank of costs** – costs of assessor of a given standard; Assessor – an external specialist employed for the needs of implementation; Change Champions, Specialists in the application of ecological methods in construction processes - employees delegated to the above works; Internal and external trainings.
2	Introduction and application of the principles of the Circular Economy (*pol*. GOZ)	Public institutions and all stakeholders of the construction market	**Low rank of costs** – the actual application of the new adopting rules in the regulation; Change Champions, specialists in the application of ecological methods in construction processes - employees delegated to the above works; Internal and external trainings.
3	Adoption of the ISO 1400X series of standards for the environmental impact management	PKN (relevant Technical Committee)	**Low rank of costs** – development of the Polish version of the standard; Works within the relevant PKN Technical Committee
4	Applying the ISO 1400X series of standards standards for	Public institutions and other construction market stakeholders	**Low rank of costs** – adopting new normative principles; Change Champions,

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
	the environmental impact management			Specialists in the application of ecological methods in construction processes - employees delegated to the above works; Internal and external trainings.

7.20 Node E4 (Ecology in the Operational Phase)

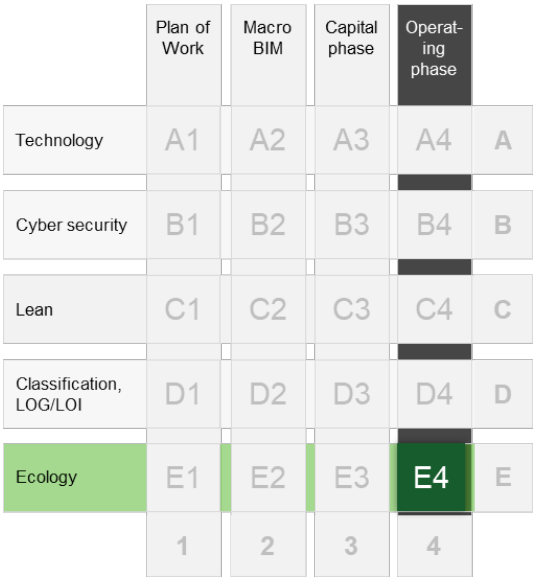


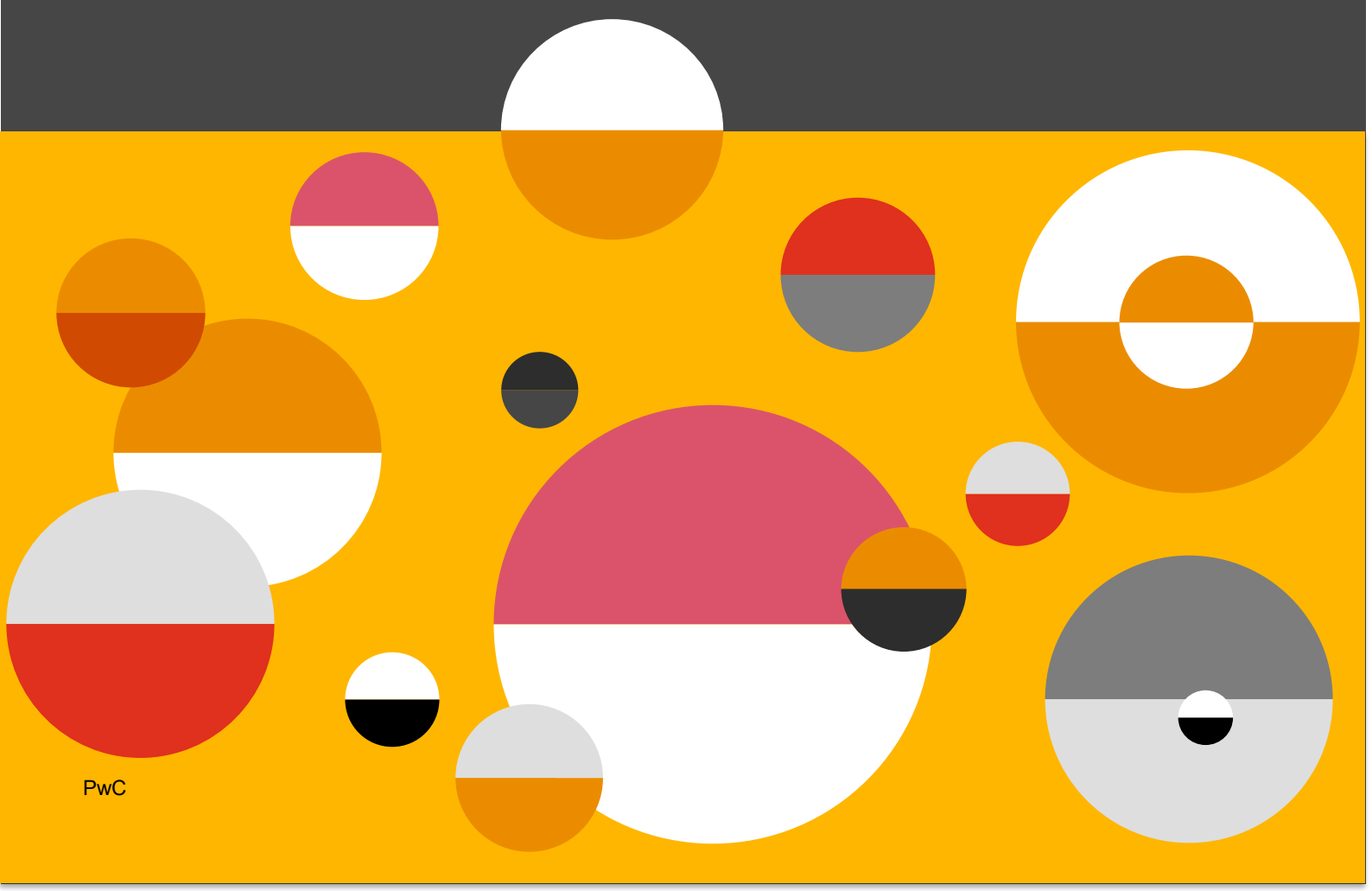
Figure 90: Node E4.

Own elaboration

Table 27. Package E4

Status, order	Package components	Notes	Responsible entities	Necessary costs and assets
1	Amendment to the Regulation on the method of calculating the cost of lifecycle for buildings and the method of presenting information on these costs (Journal of Laws 2018 item 1357)		Minister competent for economy	**Low rank of costs** – costs of amending the act; Steering Committee; On the leader's side resources will be needed to prepare and carry out the legislative changes
2	Applying the methods of the building life cycle cost calculation and the method of presenting information on these costs		Public institutions and other construction market stakeholders	**Low rank of costs** – adopting new rules from the regulation Change Champions, specialists in the application of ecological methods in construction processes - employees delegated to the above works; Internal and external trainings.

VIII. Timeline



8 Timeline

8.1 Nodes of matrix as a schedule

Presenting complex integrated processes on the axis of their development over time is a complex task. Some of their elements are usually easier to absorb and put into practice, others require more investment. The possibility of implementing the second group is often influenced by external or internal factors difficult to define or predict, or their combination. Therefore, to facilitate the coordination of the schedule for implementing BIM in Poland, the strategy described above under the Roadmap has been divided into elements and their common nodes and thus entered the spatial time chart. Recommended updates of the Roadmap for Poland may introduce time corrections for the maturity level of individual matrix nodes. The matrix concept is prepared for such corrections.

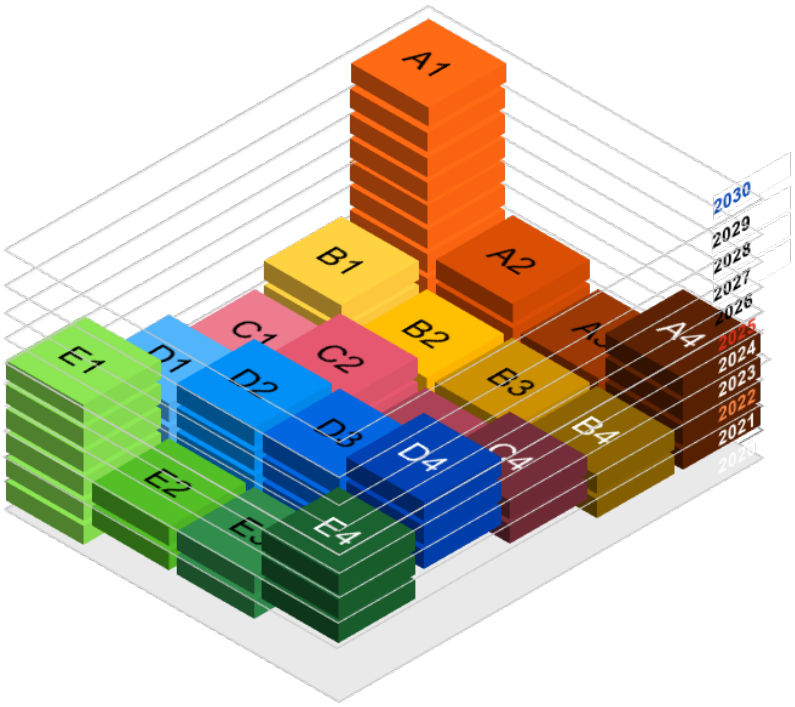


Figure 91: 3D schedule

Own elaboration

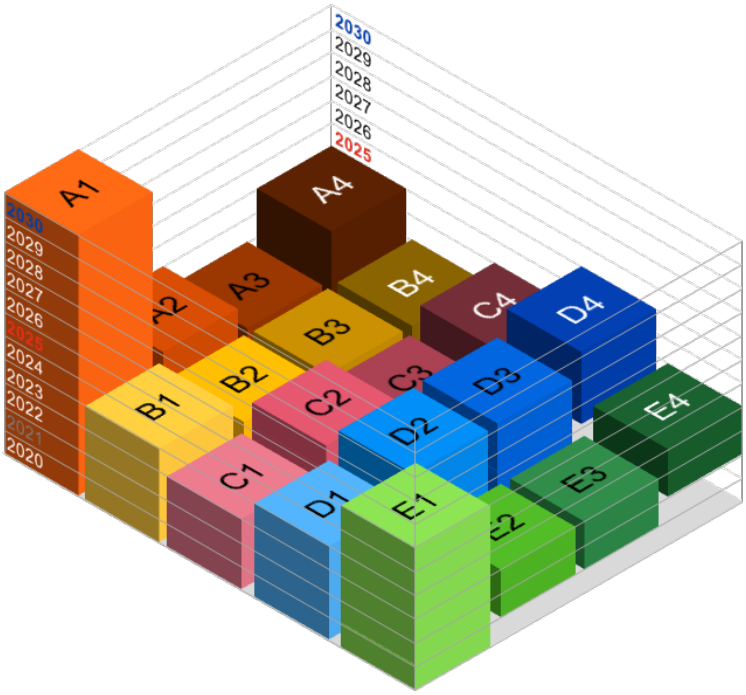


Figure 92: 3D schedule, #2.

Own elaboration

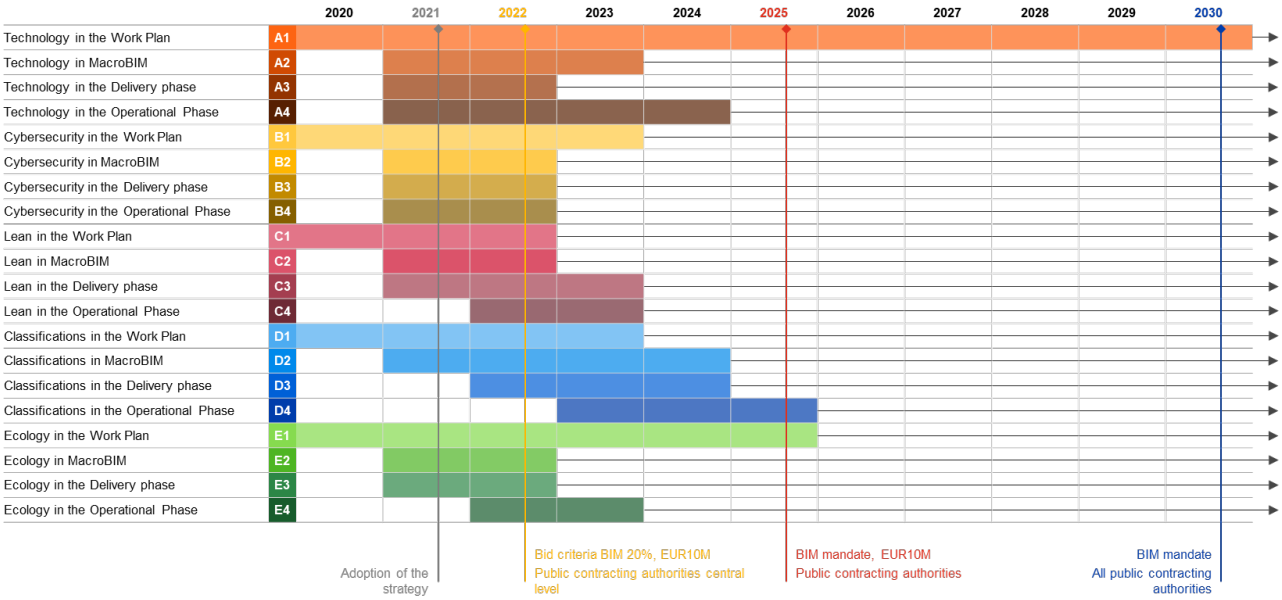
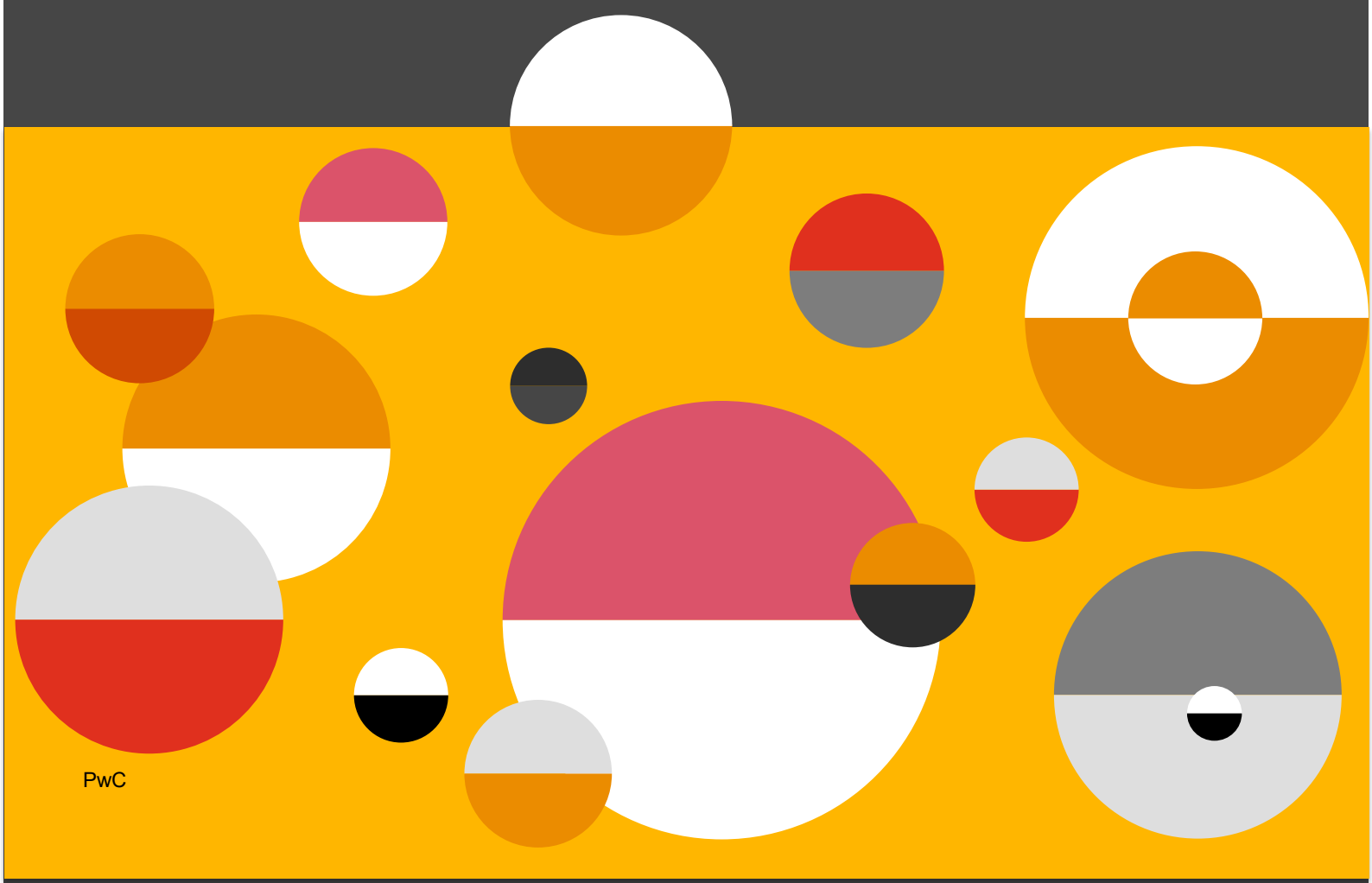


Figure 93: 2D schedule Own elaboration

IX. Key success factors



PwC

9 Key success factors

The strategy of small steps in the zero-one system (there is-there is not) is recommended as measurable success criteria. In this way, it will be possible to assess whether the institution, organisation or Integrated Team for a specific investment is following the right path to achieve the objectives presented in this study.

Given the veriety of investment types, it is not possible to include all elements and factors necessary for the implementation of BIM in Poland. However, the more of them are identified and implemented, the greater the chance of a successful BIM implementation. It is important to consistently pursue the goal of integrating and visualizing each construction investment in the BIM methodology in cooperation with all parties to the construction process.

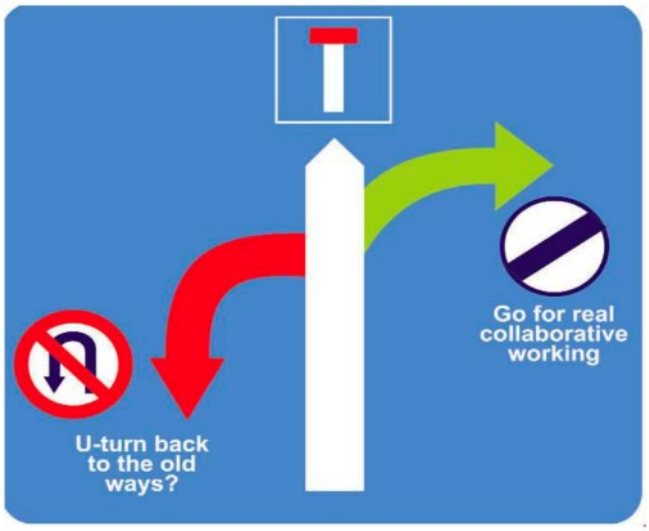


Figure 94: Illustration of the road to BIM through cooperation. [36]

Below are some examples of steps from which it is recommended to start the BIM implementation process.

EACH OF THESE ACTIVITIES, EVEN THE SMALLEST ONES, WILL ADVANCE THE BIM IMPLEMENTATION PROCESS IF IT IS REPEATED CONSISTENTLY.

9.1 Criteria for the Work Plan (preselection)

- Joint declaration of all parties to carry out an investment in the BIM methodology,
- Record the investment goals by the contracting authority using the POP tool.

9.2 Criteria for the MacroBIM phase (preselection)

- Assembling a cross-industry team to create a workable conceptual solution for the MacroBIM offer,
- Getting the contract signed at least in the “design-build” formula,
- Application of sustainable design methods to develop the MacroBIM offer concept,
- Proposing and negotiating the Target Cost of the investment,
- Conduct BIM and Lean initiating workshops.

9.3 Criteria for the delivery phase (preselection)

- Build the entire team operating without exception in the BIM methodology,
- Divide the competences of the Integrated Team into a decision-making Core Group and task groups (as in the 19650-1 standard),
- Establish nearby the construction site the Big Room for the duration of the design and delivery phase for the cooperation of all participants in the process,
- Create an incentive framework (e.g. division of savings generated in the process between all main parties – the Core Group),
- Create by the lead appointed party a BEP (BIM Execution Plan) acceptable to the appointing party,
- Preparation of a common catalog of risks (including risks related to the implementation of BIM) and a declaration of jointly solving emerging threats as well as regular joint risk analysis and updating of the risk register,
- Establish a CDE platform (Common Data Environment),
- Train the BIM modelers in the exports to IFC from native applications,
- Set up in the site office a BIM kiosk for the CDE technological service,
- Carry out 3D clash checking in a federated model in a BIM management application on site / Big Room and clash reporting,
- Match Data Drops requirements for specific and measurable investment milestones,
- Create cost estimates only from 3D design models, not from 2D drawings,
- Set up in a construction office and use the 6 boards to visualise the tasks to be performed;
- Create an intelligent spreadsheet for constant monitoring of the Target Cost of the investment.

9.4 Criteria for the operational phase (preselection)

- Consult with the Integrated Team the information requirements for asset management during asset design and delivery,
- Asset management with models, not paper documentation,
- Use COBie files generated from the model (in the form of tables in a spreadsheet) to manage repairs of system components and spare parts orders.

9.5 BIM implementation criteria for Poland

It is recommended to adopt key success factors consistent with the steps of the implementation plan for Poland, specified in matrix nodes. As a tool for monitoring the progress of introducing BIM on the Polish market, 2-3-year reports updating the status of implementation are recommended. Reports should be coordinated by the Steering Committee created under the leadership of the minister competent for economy.

A similar practice of monitoring the BIM implementation process is observed in Germany and Spain. As the first practical step in the implementation of BIM by public entities in Poland, it is recommended to carry out selected pilot projects. Similar recommendations can be found in the Czech and German strategies, which were described in Chapter 2 of the document (items 2.3 and 2.4.3).

This project, in other modules, contains BIM templates that are part of the information requirements for the asset creation and delivery phase. These templates, in conjunction with the basic criteria described above, should be the starting point for measurable implementation successes, for all significant phases of specific projects. It is recommended to monitor all activities and save the results in order to catalog the operating procedures and to avoid errors in subsequent implementation projects.

Practical experience gained in pilot projects will also help in raising BIM qualifications of all participants of the process, including representatives of the public appointing party. Therefore, full commitment of all parties is required, and as stated in the introduction to the PN-EN ISO 19650-1 standard, the resulting close cooperation in order to ensure liquidity and avoid losses in the exchange of information about the asset.

The process of BIM implementation in Poland should be based both on top-down activities (legislative, normalisation, standardisation and pilot projects) as well as self-organisation of the construction market in the form of bottom-up activities based on the cooperation of appointing parties with lead appointed parties (organisation of work in Lean methodology, integration of processes, systems and information). Each investment using BIM is a joint work of all participants of the investment process.

9.6 Further recommendations

In addition to the actions and steps for the implementation of BIM in Poland, presented in the document, it is recommended to take other steps in the next stages to introduce comprehensive digitisation of the Polish construction industry, including in particular:

- preparing legislation on the Construction Law for conducting digital processes for obtaining a building permit (as well as notification processes).
- preparation of local authorities to process the construction documentation in non-paper form and the designers to deliver non-paper documentation, including use of digital signatures; systematising the names and forms of digital documents so that the information about the design intention is clear and that its content is readable from the name of the files. It will be a preparation for the next evolution of the exchange of design information in the form of digital multidimensional models, also in publicly available open formats, normed by ISO standards; supplying all products and materials on the construction market with identification codes to further improve the digital supply chain. In this way, the combined information will be retained for the entire life cycle of the facilities and will enable smooth management of assets, as well as further transfer of digital information about the asset to its digital twin;
- capacity building of the industry members to meet the forthcoming digitisation tasks (not only in terms of BIM);
- basing on the adopted Roadmap prepare and develop a detailed BIM implementation strategy for Poland, broken down into scopes, tasks, entities and adequate cost scales;
- monitor the results of using MacroBIM in pilot projects (if this option is endorsed for implementation).

These steps, as well as other, not listed here, go beyond the scope of this project, but will complement the process of digitalisation of Polish construction, of which BIM is only the beginning.

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