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Actions to realize efficient project risk management using the BIM method

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Abstract –

At the beginning of a construction project, cost, time and quality are defined, which must be adhered to throughout the entire construction process. Compared to other industries, risk management in the construction industry is often treated negligently. Risk management is rather an additional documentation task than an effective project management and controlling instrument. However, systematically applied risk management and successfully implemented counter-measures offer the opportunity to significantly increase the result of the construction project. Information gained from an efficient risk management system can automatically be used as empirical values for subsequent projects, thus increasing the achievement of quality, cost and time targets in the long term. The application of the BIM method opens up new possibilities in terms of the automatic linking of risk management information to other processes, which have not been exploited to date.

The research project "BIM-based risk management" examines the application of risk management in construction projects on the basis of literature research, numerous interviews with experts and an online survey. The content of the analysis is the strategy of companies in implementing the classic phases of the project risk management process consisting of risk identification, risk assessment, risk control and risk monitoring. The result shows, that there is no consistent systematic approach to the use of risk management systems in the construction industry. Individual approaches, such as the use of Excel templates to identify risks, are being implemented, but there is no linking of information across projects or departments, which means that the great potential of project risk management is not sufficiently exploited.

On this basis, the research project develops an ideal-typical process for the application of risk management in construction projects. The resulting BIM use case risk management shows how this information can be automatically generated and made available via the BIM process.

Keywords –

risk management; Building Information Modeling; project risk management; risk management process; information delivery; Data linkage; Information controlling; Risk

1 Procedure and principles

Within the framework of the research project "Measures for the implementation of an efficient project risk management by using the BIM method" of the chair of Construction Management of the University of Wuppertal, solutions are being developed how the information linkage associated with the application of the BIM method can be used to improve risk management. The classical risk management process (see Fig. 1) based on DIN ISO 31000 is a sub-area of project management which is implemented over all life cycle phases of a project, involving all project participants and involving different business units. Together, the project participants identify potential opportunities and risks for the project at an early stage and take proactive countermeasures by means of the process steps of identification, assessment, control and monitoring. The risk management cycle is a continuous process. This means that the cycle is constantly repeated in the course of project processing [1]. Only project risk management is considered in the project. The aim of project risk management is to increase the transparency of risks in a construction project and to derive and evaluate measures to reduce unknown parameters and determine realistic target figures. This leads to a higher achievability of the project goals in terms of costs, deadlines and quality. Project risk

management is distinct from corporate risk management, whose overriding goal is to maintain the company.

In the research project, which has been running since January 2019, the current application of risk management in construction projects was first examined. In view of the ever-increasing demands for a partnership approach to projects between client and contractor, the project deliberately considers both sides and in particular their interfaces in terms of risk management.

Through numerous expert interviews and an online survey, the strategy of companies in implementing the project risk management process was analysed. When looking at the existing risk management processes in terms of the flow of information, level of detail and responsibilities, differences in the approaches to risk management and the priority given to the issue became apparent.

2 Risk management

The term risk refers to the deviation from project goals caused by influences on productivity. The project objective is to complete a project on time, within budget and in line with quality standards [2]. The term risk includes both positive and negative deviations from targets. The positive deviation from goals is called opportunity, the negative deviation is called danger [3]. Since mainly the negative deviations can cause construction delays and cost increases, the term risk is used in this paper to refer to the negative deviation in particular. For the correct application of a risk management system it is necessary to create an awareness of risk management in the company, the organization or the department. A risk management system must be integrated within the company or the organization or project at various organizational levels. On the one hand, it must be integrated at the normative level, where the goals of the company or project are defined. An implementation on a strategic level, determines the risk strategy to achieve the defined goals. The risk management system, the focus of this paper, is implemented at the operational level [4].

The risk strategy defines the objectives to be achieved by risk management. The risk strategy must contain the following specifications [5]:

- The type of risks to be taken
- The level of risk tolerance
- The limit of the risk-bearing capacity
- The time limit in which the risks are dealt with
- Specifications on the risk management process

DIN ISO 31000 specifies a process structure for risk management, see Figure 1 [6].

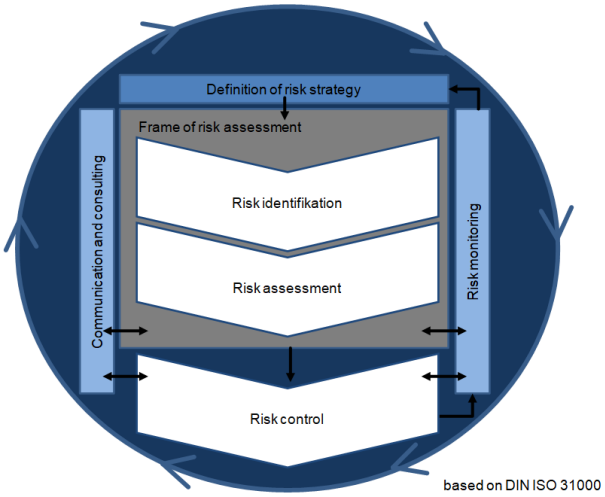

Figure 1. risk management process

The core of this process structure is transparency and openness. The process can only be successfully implemented if risks are not covered up, but are addressed openly. However, risk assessment and treatment cannot be carried out without defining an area of application, the context and setting risk criteria, see Figure 1. Throughout the cycle, continuous communication, documentation and review is required [7]. The risk management cycle is a continuous process. This means that the cycle is repeated in the course of project processing. The reason for this is that risks can change or new ones arise as the project progresses [8].

In the course of the risk management process, communication and consultation means that expertise from a wide range of fields is taken into account in the risk management process and that, as a result, different perspectives are considered in the identification, assessment, control and monitoring process. This also serves to obtain the necessary information required for risk management. Communication and consultation should take place between all those involved in the project or company [9].

Continuous monitoring and review of the existing risk management system is necessary to ensure the quality and effectiveness of risk management. In order to communicate the results of risk management, it is necessary to document risk management on an ongoing basis. This can provide information that is necessary, for example, for decision-making [10].

In order to apply a risk management process, the scope, context and criteria must be defined. This means that a risk strategy is defined as described above [11]. The definition of the scope includes a specification of the risk management processes and tools used and the necessary

means and responsibilities. A definition of the cycle of involvement and an analysis of interfaces with other projects and stakeholders are also part of the definition of the scope [12].

In addition, the environment in which the defined objectives are to be achieved must be analysed. The environment has a significant influence on the design of risk management. The external and internal relationships are defined. External interrelationships include, for example, political, legal and social aspects, whereas internal interrelationships include responsibilities and roles in the company or project [13].

Risk criteria are necessary for risk assessment. Therefore, they must also be considered. Risks can be assessed from a variety of perspectives within the company or organization, such as individual sub-projects of a major project or different levels within an organization. Since the approach and procedures differ depending on the viewpoint, criteria must be defined for risk assessment. For example, the type, extent and measurement of effects and the decision-making criteria for risks are defined [14].

3 Steps of the risk management process

The environment of all risk management processes is the risk strategy. This is used to formulate objectives and framework conditions. The next steps are the sub-processes identification, assessment, control and monitoring. Continuous controlling, careful documentation and regular communication and advice complete the risk management control loop [15].

3.1 Identification

The aim of risk identification is to identify all existing risks that could jeopardise the achievement of objectives. In risk identification, a distinction is made between cause, event and effect. A cause results in an event that has an impact on the project objectives. This distinction is important because countermeasures for dealing with risks can only be developed if the cause of the effect is known [16].

With regard to the method of risk identification, a distinction is made between the type of recording, the time of recording and the integration of the identification into the structure of the company or project [17].

It is important to complete the risk identification before starting the analysis [18].

3.2 Assessment

In the course of the risk assessment, the probability of occurrence and the extent of damage of a risk are estimated. This can be qualitative (e.g. low, medium, high) as well as quantitative (e.g. 50%, €50,000 loss). Based on the risk assessment, it can then be decided whether or not the identified and assessed risks are handled in the following ways[19]:

- No further action is taken
- Options for risk treatment exist
- Whether further analysis is needed for understanding
- The existing control system must be maintained
- project objectives may need to be adjusted if necessary.

For this purpose, the risks that are to be treated with the highest priority must first be determined.

The assessment of risks can be divided into gross and net assessment. In the net risk assessment, only the residual risk is assessed with a countermeasure. The gross risk is therefore the purely assessed risk. The gross risk thus represents the entire extent of the risk, whereas the net risk only shows the residual risk after countermeasures. It is assumed, however, that the countermeasures to reduce the scope of the risk occur to the extent assessed [20].

3.3 Control

In the risk management process step, countermeasures are developed to deal with the risks. The effectiveness of the selected countermeasures is then assessed. If the remaining residual risk remains too high, a further or, if necessary, new countermeasure is defined. This results in an iterative process [21].

How a risk is treated depends on the risk behaviour of the company or project and the risk strategy that has been defined [22]. A basic distinction is made between cause-related and effect-related measures [23]. Cause-related measures reduce the probability of a risk occurring, whereas effect-related measures reduce the extent of damage [24].

A distinction is also made between active and passive measures. Active measures contribute to reducing the probability of occurrence and/or the amount of damage, thereby changing the risk structure. Passive measures, on the other hand, aim to minimize the extent of damage. An attempt is made to compensate for the occurrence of a risk [25]. The combination of several coping measures is also possible and common in order to keep the residual risk low [26].

A distinction is made between five different risk management strategies [27]:

- Avoidance
- Reduction
- Transmission
- Insurance
- Acceptance

With regard to the order of priority of the application of coping measures, there is no fixed order. This must be determined individually. All measures depend on the cost-benefit ratio, but also on the time schedule, the qualitative dependencies and the applicability.

3.4 Monitoring

As already explained, communication and consultation, recording and reporting, as well as monitoring and reviewing are also part of the risk management cycle according to DIN 31000, and these components of the cycle should take place at all stages of the process [28].

The risk management process of a company or project must always be reviewed. This part of the risk management process is therefore also called risk controlling [29]. On the one hand, risk controlling serves to determine whether the desired effectiveness of the management measure has been achieved. On the other hand, it serves the right insight if a risk has to be re-evaluated or a countermeasure is not effective. It must also be checked whether a risk no longer exists, for example, due to a change in planning, and whether the change in planning gives rise to new individual risks [30].

4 Study on the application of risk management in the construction industry

In order to gain an insight into the application of risk management in construction practice from the perspective of the client and the construction company, expert interviews and an online survey were launched by the University of Wuppertal. The structure of the web-based survey corresponds to that of the expert interview.

The online survey was completed at the end of September 2019. 249 participants took part in the survey. Among the participants are 50 construction companies, 47 private builders, 34 planning/architectural offices, 31 participants from the field of consulting, 25 public builders, 6 experts, 3 from the craft sector and 54 from other fields. The findings of the survey are summarized below.

4.1 Positive approaches visible in practice

Around 60% of the companies surveyed implement risk management in accordance with a uniform company-wide risk strategy. Risks are identified for the first time at the acquisition stage or at the start of a project and are continued through the subsequent project phases. Risks are usually recorded in Excel applications or the company's own software applications. Communication channels for risk management are generally short and, thanks to open discussion cultures, there are few fears of communicating risks.

The interviewed experts recognize advantages for the project business through risk management: Risks that are recognized early have a positive influence on the further course of the project. Costs are saved, customers are retained and experience and improvement potential for follow-up projects is generated. There is improved control of costs and cost transparency throughout the entire construction phase, and through the integration of the risk management system, all those involved are able to improve the reliability of deadlines and costs.

4.2 Identified problem areas

Instead of uniform guidelines for dealing with risks and a systematic approach, a good third of companies rely purely on the experience of their employees.

Risks are considered in greater depth in the bidding phase, but are neglected in the execution phase. When assessing risks, the effects of deadlines are usually not taken into account in the offer. Risk assessment is largely intuitive and is shaped by the experience of the individual employee. The risk assessment usually ends with the acceptance and is not continued until the end of the warranty. Companies often have clear divisions between the departments of acquisition and project execution or planning and implementation on the client side. After project completion, the knowledge gained is only transferred to a few colleagues in discussions at communication level. None of the companies carries out a systematic evaluation of the risks after project completion and a systematic transfer of this information to subsequent projects.

4.3 Conclusion of the study

Overall, it became clear that risk management is by no means accorded importance in every company. For about half of the companies surveyed, risk management hardly plays a role in their projects. The cost and schedule of a project is usually determined by higher authorities and the project participants lack the necessary room for maneuver. There is potential for a stabilisation of risk management processes: Regular identification of risks, adjustment of assessments and linking to other processes have so far hardly been used to make risk management more effective. There is often no consistent systematic approach to the use of risk management systems. It is more a combination of individual approaches, which are not sufficiently linked and therefore information is lost or not fully used. In view of the imbalance of many current major projects, the potential of an industry-wide application of risk management processes is evident here.

5 Outlook using BIM

The mentioned research project has the aim to show the development possibilities of risk management into the method BIM. Therefore, the participants of the study were asked for which use cases and to what extent they currently use the BIM method to generate integration potentials for risk management. The survey showed that BIM is already being used in companies. The most frequently used use case is the use case of 3D modelling and collision check. The 3D modelling is set up in the planning phase and attributes are defined to support the prefabrication process. In addition, the models are used to generate carcass and fit-out dimensions, which serve as a basis for the bill of quantities and costing. Schedules and costs are usually not yet linked in the respondents' BIM models. In some companies, there are also company specifications to digitalize the complete planning and construction processes. Tablets are also often used for construction site operations. These enable access to the documents, checklists and work aids in the cloud. In addition, barcodes are sometimes stuck into every room on the construction site and the site manager has the option of calling up the attributes and information important for the room via tablet. The complete defect management is generated daily via the tablet of the site manager and the information stored in the cloud. The areas of construction site logistics, modularization, systematization of construction products and components are currently the focus of integration into the execution. In addition, some of the construction companies also want to use their project model for later operation and extract an as-built model from the data and attributes. The aim is to use BIM to create a complete digitalization of the processes from the construction site or project. As a use case, construction companies have their own focus such as quantity take-off, calculation and quality assurance on the construction site. Developers usually use BIM to focus on 3D coordination. Documentation is an important use case for all parties involved. A market analysis of risk management software carried out in parallel to the surveys also revealed, that there is currently no BIM-capable offering, for example with an ifc interface.

5.1 Process modelled risk management

As the study shows, risk management is currently regarded and implemented as a separate process in most companies. There is currently no link to other project processes such as scheduling or cost planning. To be able to use the advantages of the BIM method for risk management, the process must first be linked to the other project processes.

The first step in linking with the BIM method in the research project is therefore to model the risk management processes and link them to the other project processes. For this purpose, the risk management process described in chapter 2 and 3 was created/modelled with the help of the Business Process Modelling Notation 2.0 (BPMN 2.0). Figure 2 shows an extract of the process and gives an overview of the type of modeling.

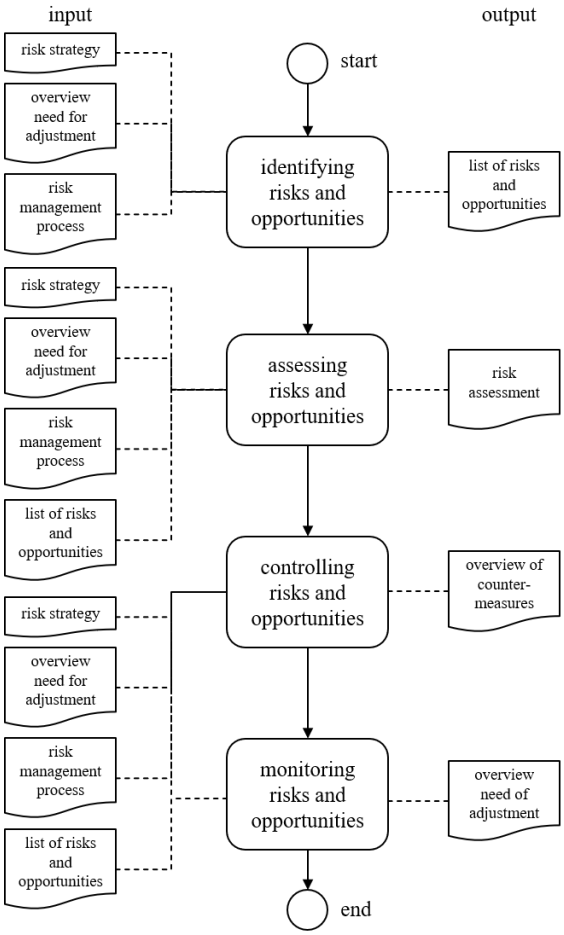

Figure 2. risk management process in BPMN 2.0

Each step of the risk management process shown in Figure 2 is broken down in more detail in further levels of the process model. The process "Identifying risks and opportunities" is divided, for example, into the process steps "Describing risks/opportunities", "Defining a short description", "Determining the cause and effect of the risks" and "Assigning a risk/opportunity category". In this way, all process steps are linked to one another and clearly presented.

In a second step, the modelled risk management processes are then linked to the other processes of the shown project, for example, cost control. In this way, it becomes clear at which point in the project, risks must be identified, assessed and controlled on the one hand, and which processes provide information in order to better

assess risks on the other. Figure 3 shows an example of this information linkage.

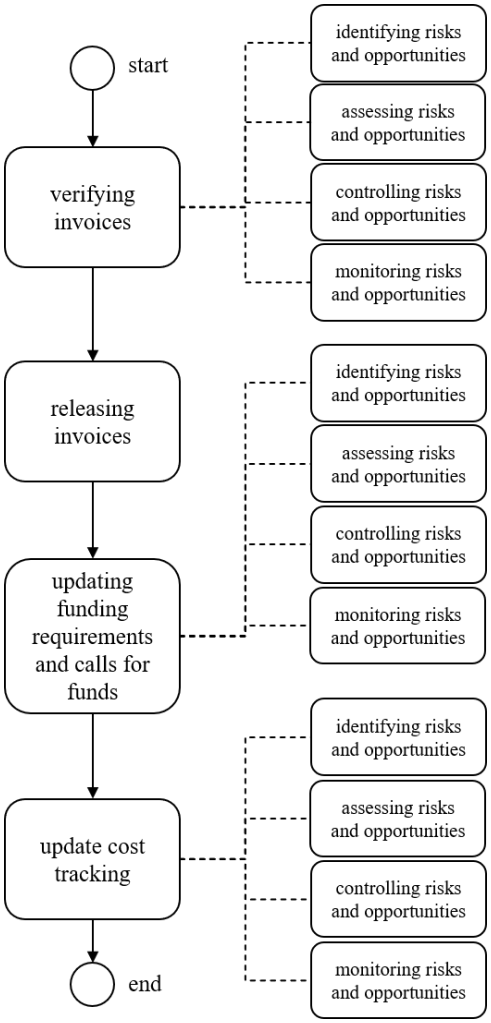

Figure 3. risk management processes linked to the process of cost management

The risk management process is represented on the process level, in which the methods and digital tools of a construction project are applied. The documents required for the risk management process in this section are formulated at a deeper, more detailed level.

The created risk management process now serves as a support process for the process steps in a construction project over the complete life cycle phase. In the further course of the research project, critical paths/processes in a construction project are analysed and the support process is integrated into them. This resulted in an overview of the critical processes for the different phases and from the point of view of the client and the construction company. Helpful tools and documents are formulated for each of these processes. The overview serves to link and identify potentials for the application of BIM.

6 Outlook research project BIM-based risk management

Processes have to be concretized, digitalized in the companies and responsibilities defined. Forms in the company and in the individual project phases must be digitalised and linked to software options. Checklists and required documents should be maintained regularly through experience and market adjustments and should be centrally stored for each employee.

In the further course of the research project, which will run until the beginning of 2021, optimization possibilities will be worked out based on the results of the survey so far and further potentials will be identified by using digital tools. A short self-check was developed for companies interested in a check of their own risk management processes. By ticking off the points, both approaches already successfully applied are made clear and ideas for further potential are offered.

In the coming months, a possible integration of the Building Information Modeling (BIM) method will be examined. To this end, the first step will be to link the risk management processes with the other processes of a construction project. The resulting process model will then show which information from the project activities should be used for risk management and, vice versa, which information is generated by risk management for the further course of the project. The BIM method is intended to enable a structured collection of risk management data. With increasing planning accuracy, the linking of information can be continued down to the component level. The linking of identified risks with components of the digital building model in the realization phase, promotes the integration and thus the acceptance of risk management and visualizes its advantages for the project result. The principle of the BIM method "first plan - then build" allows an early consideration of risks already from the planning phase to increase the reliability of deadlines, costs and quality.

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