CZECH TECHNICAL UNIVERSITY IN PRAGUE

Faculty of Civil Engineering

Department of Economics and Management in Civil Engineering

Risk management in construction project delivery methods – hotel buildings

Diploma Thesis

Study Programme: Civil Engineering

Branch of study: Construction Management

Thesis advisor: Ing. Martin Čásenský, CSc.

Bc. Michaela Frýdlová

Prague 2016

I declare that I made my diploma thesis on my own research based on consulting with my thesis supervisor Ing. Martin Čásenský, CSc.

Furthermore I declare that all sources used in this work are cited in the list of references.

Prague, 8.1.2016 signature

RISK MANAGEMENT IN CONSTRUCTION PROJECT DELIVERY METHODS - HOTEL BUILDINGS

ACKNOWLEDGEMENTS

I would like to thank my thesis supervisor, Ing. Martin Čásenský, CSc., for his support, guidance and advices throughout this research. I highly appreciate it.

LIST OF ABBREVIATIONS

C	Contractor
CM	Construction management / manager
CWPG	Construction works procurement guidance
D&B	Design and build
DBB	Design - bid - build
ECI	European Construction Institute
EMV	Expected monetary value
ER	Extreme risks
ETA	Event tree analysis
FTA	Failure tree analysis
H	High
HR	High risks
IM	Impact
IRR	Internal rate of return
LH	Likelihood
LR	Low risks
M	Moderate / medium
M&E	Mechanical and electronical
MR	Moderate risks
ORA	Overall risk assessment
PMBOK	Project management body of knowledge
S	Subcontractors
TC	Total cost
thsd.	Thousands
VH	Very high
VL	Very low
WLCC	Whole life cycle costing

ABSTRACT

The task of this diploma thesis is to describe some theoretical knowledge of risk management, to apply risk management tools and techniques to real construction projects and to compare risks of possibly used delivery methods of these projects. Managing risk is an integral part of good management, and fundamental to achieving good business and project outcomes and the effective procurement of goods and services. This work is concentrated on specific projects of hotels and the handling of all risks the projects might face in each phase of the project life cycle. The main aim of this work is to analyse relation and extent of risks in each stage of project to achieve desirable results of the project by defining and implementing management processes of project risk and to determine which of the delivery methods would have been the best solution for projects of hotels.

KEY WORDS

Risk management, project life cycle, whole life cycle of construction, construction project delivery methods, hotels

ABSTRAKT

Předmětem této diplomové práce je charakteristika teoretických znalostí risk managementu, použití metod a technik řízení rizik v reálných stavebních projektech a porovnání rizik jednotlivých dodavatelských systémů použitých na tyto projekty. Řízení rizik je nedílnou součástí správného managementu, je nezbytné pro dosažení dobrého obchodu a výsledků projektu a efektivního zadávání zakázek. Tato práce je zaměřena na konkrétní stavební projekty hotelů a na řešení všech rizik, kterým tyto projekty můžou v jednotlivých fázich životního cyklu čelit. Hlavním cílem této diplomové práce je analyzovat vztah a míru rizika v jednotlivé fázi projektu k dosažení žádoucích výsledků, prostřednictvím stanovení a zavedení procesů řízení rizik, a určit metodu dodavatelských systémů, která by byla nejvhodnější a nejvýhodnější pro projekty hotelů.

KLÍČOVÁ SLOVA

Risk management, životní cyklus výstavbového projektu, životní cyklus stavby, dodavatelské systémy staveb, hotely

CONTENTS

1. INTRODUCTION

The definition of the term *construction* is relatively difficult to accurately describe, although we use it every day. With this word we can express the process of creating and building infrastructure or the result of these acts. As Civil Engineers we will daily face challenges as construction projects, no matter at what phase of the project life cycle. Construction project is a unique, complicated conversion of idea on paper to real product; it is also unrepeatable time-limited intention with cost and quality targets. There may be a lot of problems to deal with. "*No construction project is risk free. Risk can be managed, minimized, shared, transferred or accepted. It cannot be ignored."*[1]

Risk management is one of the important processes of Project management, especially if it is a large and expensive project in which are many factors influencing outcome. And the construction projects fall into this category. Risks expand through the whole project life cycle; identification of the risks and making right decision of the handling with them are very significant factor leading to prosperity of all stakeholders.

During my study at Czech Technical University I worked in the financial department of the Czech subsidiary of the world's leading hotel operator. This opportunity and experience approached me to the hotel industry and gave me another view than Civil Engineer has. And for these reasons I chose task of my diploma project that I know both side of the hotel construction, as a Civil Engineer, especially Construction project manager, or as an owner's advisor.

[1] LATHAM, Michael. *Constructing the team*, p. 14.

1.1. AIM OF THE RESEARCH

The primary aim of this study is to analyse relation and extent of risks in each stage of project life cycle to achieve desirable results of the project by defining and implementing management processes of project risk. And based on real projects of hotel construction and hotel reconstruction there will be determined which of the delivery methods would have been the best solution for projects of hotels.

1.2. RESEARCH OBJECTIVES

The objectives of this research are:

- To apply risk management tools and techniques to real construction project
- To analyse relation and extent of risks in each stage of project life cycle
- To compare risks of possibly used delivery methods
- To determine a delivery method which will be the best for projects of hotels

1.3. STRUCTURE OF THE THESIS

This diploma thesis can be divided into two main parts; theoretical and practical part.

In the theoretical part there will be summarized knowledge that I achieved during my study at Czech Technical University in Prague, my part-time job at the hotel and preparation to this thesis. The theoretical part will interpret problems construction projects faced during whole life cycle and how risk manager solves them. These contributions are sorted into different sections, such as Construction projects - Project life cycle, Project delivery methods; Project stakeholder management – Identification, Managing stakeholder engagement and Risk management – Risk identification, Risk analysis, Risk responses.

In the practical part there will be applied the knowledge of Risk management on two real construction projects of hotels. One is construction project of the hotel building in Prague; the second one is conversion of the House of Trades union services into hotel building. On these projects there will be analysed stakeholders, identified risks, conducted risk assessment, introduced risk strategies and risk treatment. And based on that the best delivery method for hotel construction projects will be determined.

2. CONSTRUCTION PROJECTS

The construction project is a complex undertaking and numerous people, activities, and requirements are involved to accomplish the goals set forth by owner. The whole design and construction process is very straight and requires a systematic, comprehensive approach. Each of the stage is unique, and specific management techniques and skills are needed to keep everything on track. The project team works together in a coordinated effort. There is a lot at stake and everyone looks forward to a successful completion of the project.[2]

2.1. CONSTRUCTION LIFE CYCLE

The design and construction follow a consistent linear path from initial concept to occupancy. We move through the process one step at a time, eventually arriving at the successful delivery of the construction project. A project may be divided into any number of phases. The phase structure allows the project to be segmented into logical subsets for ease of management, planning and control. The number of stages, the need for them and the degree of control applied depend on size, complexity and potential impact of the project. It can be divided into these stages:[3]

- Design and Bidding
- Pre-construction
- Procurement
- Construction
- Post-construction
- Owner occupancy

[2] JACKSON, Barbara J. Construction management jumpstart, p. 117.

[3] JACKSON, Barbara J. *Construction management jumpstart*, p. 117-118.

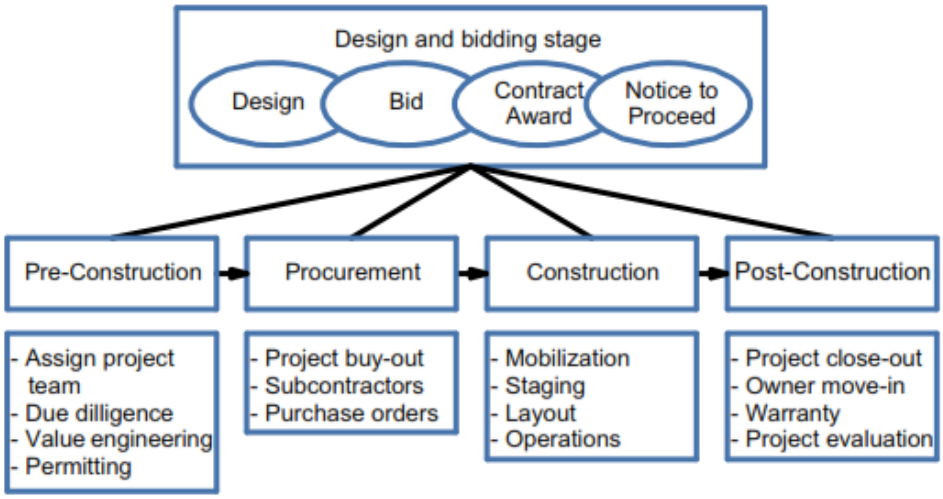

Figure 1: STAGES OF THE CONSTRUCTION PROJECT (Source: Jackson 2010)

2.1.1. DESIGN AND BIDDING PHASE

Every project starts with a design and the design process involves an intensive study and a lot of considerations. The architects and engineers basically converse ideas on a paper combined with certain requirements of owner into intelligible plans and specifications that are used to build the new construction. Traditionally, contractors are not directly involved in the design process unless the picked project delivery method includes design, such as design-build contract. But whether or not they are involved in this stage, good contractors are aware of what occurs during this first step in the project sequence.

The design process we can split into four steps[4]:

Programming and feasibility

- Owner and end user's clarification of needs, goals and objectives for the facility, requirements, discussion of the project budget

Schematic design

- Rough sketches identifying general spaces and adjacencies, shapes, orientation; consideration of materials, sizes, etc.; preliminary specifications and estimates

Design development

- Detail work; performing of the value engineering and constructability reviews

Contract documents

[4] JACKSON, Barbara J. *Construction management jumpstart*, p. 118-120.

- The final detailed drawings incl. final specifications; the quality of these documents is very important because of the changes within the construction

These steps are sequential and build on one another. As the designers work through the process, they move the design from concept to detailed drawings.

The design phase culminates with the competitive bidding stage. After final drawings and specifications there is time to select the builder.

Risk management in this phase:
The contractor is usually not involved until after the final design stage. Therefore the ability of the parties to influence project outcomes, including reduction of cost, creation of additional value, improvement of performance and flexibility to incorporate changes is much higher in the earlier conceptual and design stages of the project.

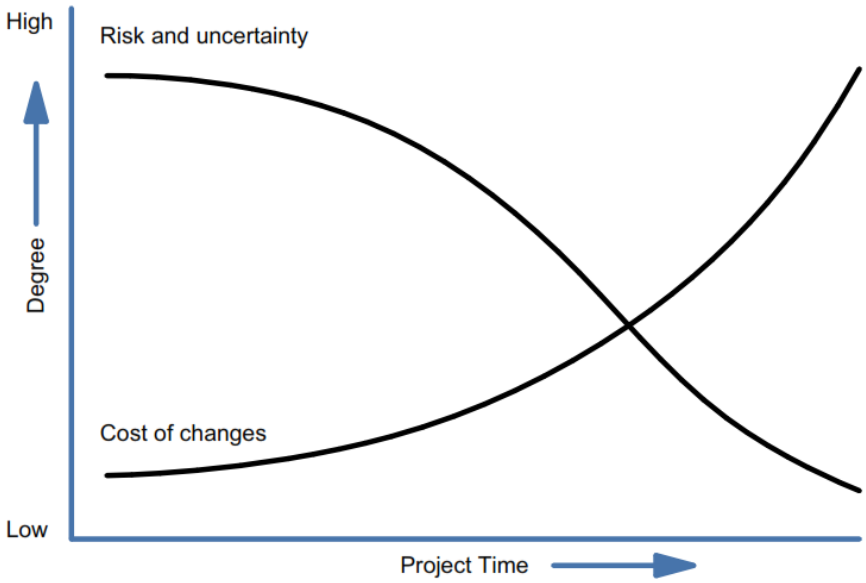

Figure 2: IMPACT OF VARIABLE BASED ON PROJECT TIME (Source: PMBOK)

2.1.2. PRE-CONSTRUCTION PHASE

In this stage, after the final drawings and the selecting of contractor are done, there is a need to forward it to the project team.

The pre-construction process we can split into four steps[5]:

Assign project team

- First task of Project manager => to choose the right person to the right place of his project

Due diligence

- Identifying of problems or areas which could arise

Value engineering

- This process may or may not be conducted during these phase, depending primarily upon which project delivery method is being used
- Optimization of the resources to achieving the greatest value for the money being spent

Permitting and Inspection process

- The acquirement of building permits; the inspections during the construction project

Risk management in this phase:

The key to good project planning is the ability to anticipate potential problem before they become actual problems. Very important thing is that the project manager really understands the project goals and come up with a plan that will ultimately meet the owner's expectations for time, cost and quality.

Surprises increase risk and they are not welcome during construction – they hinder the work progress, impacting the schedule, the cost and in some instances even the quality of the job.

2.1.3. PROCUREMENT PHASE

The procurement stage of construction management is often referred to as "buying out" the job or purchasing the labor, materials and equipment needed to complete the project. A great deal of the construction management function has to do with managing contracts

[5] JACKSON, Barbara J. *Construction management jumpstart*, p. 121-127.

– contracts to secure the labor and trades needed to perform the work, and contracts to secure the materials and equipment that will be placed on the project[6].

The procurement process we can split into three steps[7]:

Project buy-out

- Converting all subcontracts bids to subcontracts and all material quotes to purchase orders

Subcontracts

- Buying trade labor through subcontracts

Purchase orders

- Managing all deliveries of materials

Risk management in this stage: Price is not the only aspect to choose the subcontractor; we must also count on the quality. Order mishaps and delayed deliveries can have major consequences for the contractor and the owner both time and especially financial. Poor preparation in this phase can cause serious problems in the following stages. That must be avoided.

2.1.4. CONSTRUCTION PHASE

This stage is the main process of construction project; it is the phase of actual realization of the idea on a paper. This includes laying out the foundation, placing the concrete, laying the block, setting the steel, framing the walls, installing the roof, installing the electrical, running the plumbing and every other construction activity needed to complete the facility. As the construction moves forward, the ultimate goal is to keep the project on schedule, within budget and of high quality.

The construction process we can split into four steps[8]:

Mobilization

- Setting up and getting ready to start construction

[6] JACKSON, Barbara J. *Construction management jumpstart*, p. 127-128.

[7] JACKSON, Barbara J. *Construction management jumpstart*, p. 127-128.

[8] JACKSON, Barbara J. *Construction management jumpstart*, p. 128-130.

- Setting up of the field office or temporary storage facilities; development of a materials and handling plan; security of temporary electric or water service; establishment of safety programs and protocol; etc.

Staging

- Strategy of the highest productivity and efficiency of movement

Layout

- Formulation and diagram of a site layout plan

Operations

- The construction itself from the site work to the roofing and all finishing works; coordination of all labor, activities and materials on the job site

Risk management in this stage: At this moment, everything should be perfectly planned; but there are so many influencing factors that it is impossible to ensure avoiding single problem. One of them can be the fact that every construction project brings together a new group of people, most of whom are working together for the first time. In this stage there is an enormous amount of coordination among the trades that must take place during construction. The keys to successful coordination are proper scheduling, preparation and planning.

2.1.5. POST-CONSTRUCTION PHASE

The construction project is not finished by construction phase, there is more to do. The post-construction stage is also needed.

The post-construction process we can split into four steps[9]:

Project close-out

- The completion of final standard procedures as: project punchout, substantial completion, final inspection, Certificate of Occupancy, commissioning, final documentation, final completion

Owner move-in

- Handover the keys to the owner

[9] JACKSON, Barbara J. *Construction management jumpstart*, p. 132-138.

Warranty

- Correction period
- Express warranties (written into the contract), implied warranties (established or required by law)

Project evaluation

- Assessment of the results and the work of project team during the construction

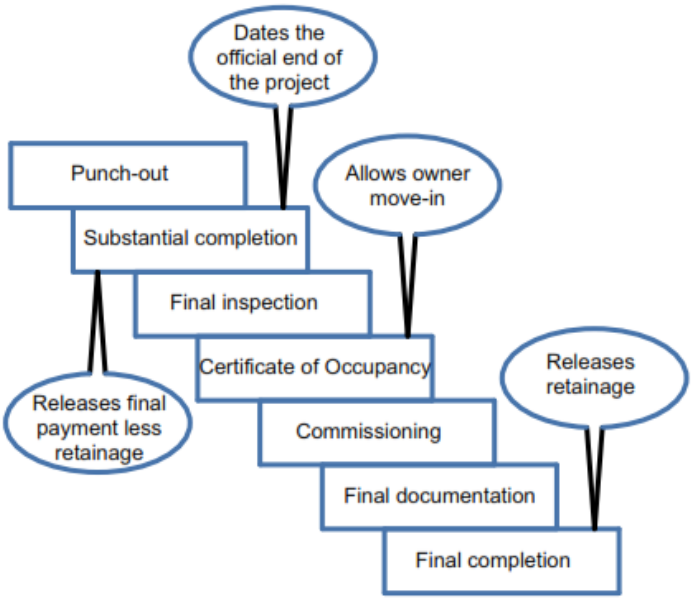

Figure 3: PROJECT CLOSE-OUT PROCESSES (Source: Jackson 2010)

Risk management in this phase:
The building has been constructed and contractor hands over the keys to the owner. Most of the problems implemented in the risk analysis already occurred but there could resurface what was ill-defined in the contracts.
The project manager should take the opportunity that he has summary of the construction project, both good work and mistakes, and use or avoid them in the future.

2.1.6. OWNER OCCUPANCY PHASE

The building is passed on the owner; but for him it is not over. The most expensive part of the construction life is in front of him. The costliest part is primarily caused by the fact that this stage is the longest of the whole life cycle.

Nowadays there is often used term of facility management. The facility management is multidisciplinary field which plans and operates all the supporting activities of the company.[10,11]

The owner occupancy process we can split into five sections:

Operation

- Ensuring of the running of the building such as energy supply, water supply, waste disposal, insurance, etc.

Maintenance

- Ensuring of the operability of the building
- Maximizing of the life of equipment; prevention of the defects and failures discovered during the operating stage

Repairs

- Correction of the defects and failures discovered during the operating stage

Reconstruction and Renovation

- Modernization and remodelling of the building

Termination

- Removal of construction

Risk management in this phase:

Any future investment in the existing stock such as renewal and replacement of building elements, review of existing facilities and future demands on energy supply all have associated with risks.

Society develops and that brings various changes and requirements. For example nowadays there are established higher and higher demands on energy efficiency; and therefore it is good to be prepared and count on that within a few years they could increase and there will be a need of renovation or purchase more effective facilities.

[10] VYSKOČIL, Vlastimil K. *Facility management*, p. 12-16.

[11] ŠTRUP, Ondřej. *Základy facility managementu*, p. 15-17.

2.2. LIFE CYCLE ISSUES

During the whole life cycle of the building there are many issues which should be faced. Every construction project is unique and every project deals with something different. It also depends on the types of projects; how the project is complicated or whom it involves.

The owner needs to know in advance what he will face, what the project will cost and especially how much he will earn; therefore the technique of the whole life cycle costing "WLCC" emerged in the construction industry. It is fundamental part of a decision-making process. The main goals are to achieving optimised value for money, the risks that must be managed and the arrangements for the transfer of risk to a single best qualified structure.[12,13]

The key issues are:

- Meeting clients' expectations
- Sustainability
- Monitoring performance of constructed assets
- Monitoring cost effectiveness of constructed assets

One of the basics in investment decision is quantification of whole life cycle costs. For better quantification the costs could be divided into groups. The division could be different.

The whole life cycle cost could be split into six sections such as:[14]

Cost of finance

- Non-structural expenses

Capital cost model i.e. design and construction

- All costs arising in the course of phases from the design to post-construction

Cost of renewal

- Costs for correction of the defects and failures discovered during the operating phase

Operational costs

[12] ECI, *Public private partnerships*, p. 51-60.

[13] BOUSSABAINE, Halim A. *Whole life-cycle costing*, p. 3-4, 12-14.

[14] SCHNEIDEROVÁ HERALOVÁ, Renáta. *Udržitelné pořizování staveb*, p. 85-91.

- All costs to ensuring the running of the building such as energy cost, water cost, insurance, etc.

Maintenance costs

- Costs to ensuring the operability of the building
- Costs for prevention of the defects and failures discovered during the operating stage

Disposal costs of the building

- Costs of demolition, debris removal, recycling

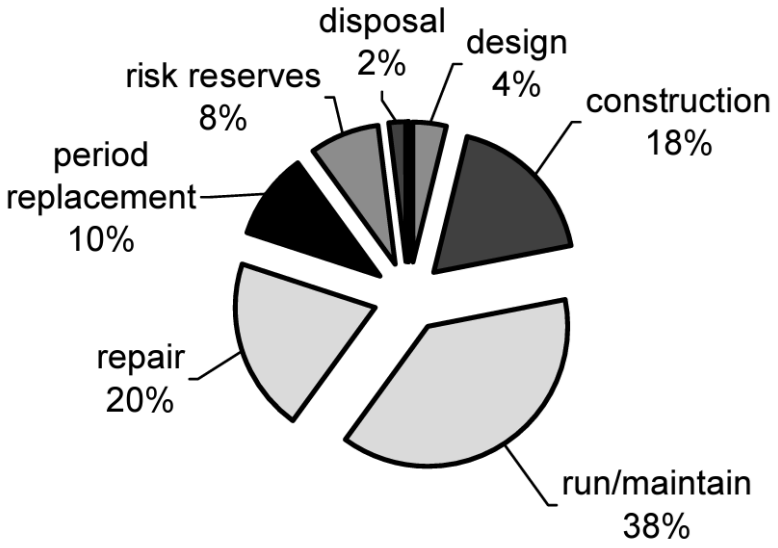

Figure 4: BENCHMARKING COST OF TOTAL OWNERSHIP (Source: Boussabaine 2004)

For the reason of modelling costs during the whole life cycle (e.g. 30 years) there is a crucial role of the time value of money.

"The time value of money concept is a reflection on the fact that present capital is more valuable than a similar amount of money received in the future. Time value of money computation is based on present value and discounting techniques."[15]

For this purpose there is a need to calculate all cost at today's rates.

[15] BOUSSABAINE, Halim A. *Whole life-cycle costing*, p. 37.

One of the most used methods of the measuring economic performance in whole life cycle costing is Internal rate of return “IRR”.

“Internal rate of return is the discount rate at which the present value of the cash flow is equal to zero or discounted revenues equal discounted costs.”[16]

The following is the formula for calculating IRR:[16] $\sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - I = 0$

C_t –cash flow during the period t, I – investment costs, t – analysed period, T – life cycle

[16] TOMEK, Aleš. *Finanční řízení ve stavebním podniku*, p. 82.

2.3. PROJECT DELIVERY METHODS[17]

During the construction project some problems always expand; cost overruns, time delays, conflicts among the various parties. It is needed to mitigate these risks. One of the best ways how to reduce is to transfer them. And it is possible by choosing the right project delivery method. Mostly it is the owner who decides which of the project delivery method use.

Project delivery method is the process of all organization of the construction project which is put together in the contracts.

There are many ways how to deliver a construction project; but the most used delivery methods in private sector are three: traditional method of project delivery (design – bid – build), design & build and professional construction management.

2.3.1. DESIGN – BID – BUILD

Traditional method of project delivery is the most used delivery method in the Czech Republic. The reason of that is the tradition, but also transparency in controlling of the project cost. In the method DBB the owner makes two deals – one with the architect and the second one with the contractor.

First the owner chooses the architect or planner to design the building or structure. He prepares the complete design ready to the bidding phase. After these plans and specifications the owner selects the general contractor who will provide the construction.

[17] VONDRUŠKA, Michal. *Project management* [lectures]

Advantages:

- Everybody in the construction industry knows that and is well-versed in it
- The management and control systems are mostly based on this method
- Searching for the contractor – investor's profit from the competitive environment
- A clear idea about the price of the work
- The possibility of a good estimate of the price of the work represents an advantageous position for the tender
- The relative simplicity of construction organization on the part of the investor
- The transfer of risks to the contractor (in absence of changes)

Disadvantages:

- Separate meetings of the stakeholders
- The contractor lacks opportunity for applying of his experiences to improving of the economy of the project
- Problems in understanding of the assignment – litigations
- This method of construction requires the strict sequence of the project phases and obstructs the time saving
- Unexpected acts require amendments to the contract
- Any changes require a price and term amendments
- The pressure on the price may lead to the use of poor-quality subcontracts

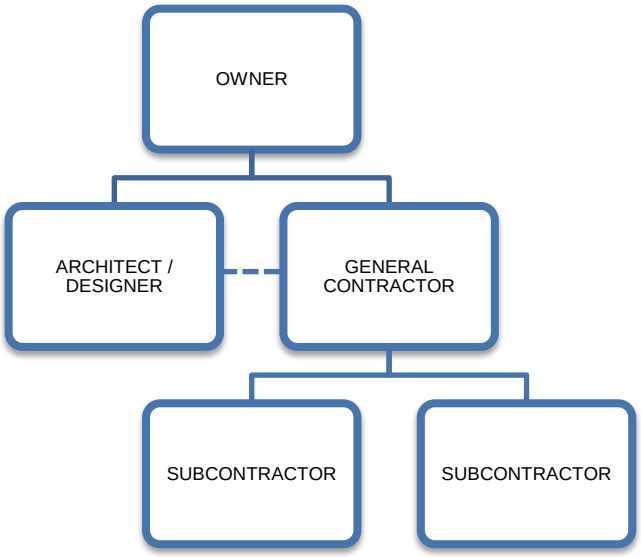

Figure 5: DESIGN-BID-BUILD (Source: author)

2.3.2. DESIGN & BUILD

In the case of D&B contracts, the owner makes a deal with only one entity which is responsible for the entire project. The entity is a construction company with his own design department or a combination of several entities involved in the project, mostly construction company and the design office.

The owner establishes requirements for the design and the execution of the project. The contractors offer design and construction. The company which covers the entire project is fully responsible for the quality, cost and timing of the work. When some problems between design and construction arise, the umbrella company will take the responsibilities. D&B company is liable for the whole project and it cannot move any defect to another party; the company is motivated to the quality design and execution.

Advantages:

- It represents a big security for the owner – the transfer of responsibility to the contractor
- The owner conclude a direct agreement with one part – the contractor, this improves communication between the parties
- The overall construction can be shortened because of *fast-tracking*
- The owner has a total cost of project after signing of agreement

Disadvantages:

- The owner loses some control over the project by transferring the risk to the contractor
- Any request that was not precisely specified in the documentation will mean a change of the contract (addendum)
- The changes initiated by the owner can be quite expensive compared to other project delivery method
- The owner must be able to formulate and communicate his vision for the project

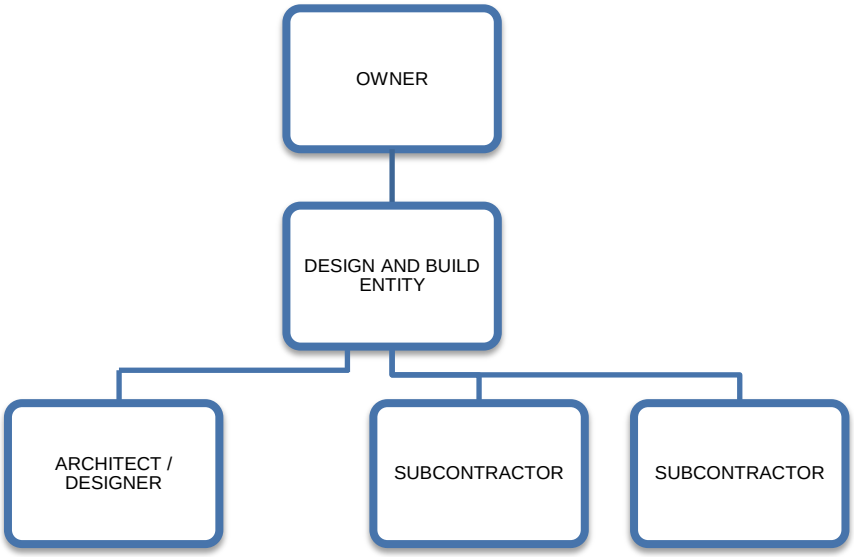

Figure 6: DESIGN & BUILD (Source: author)

2.3.3. PROFESSIONAL CONSTRUCTION MANAGEMENT

Within the system Professional construction management construction manager "CM" provides managing the work and activities for a fee. CM is, in legal terms, in the same position relative to the owner as architects or other consultants. His main task is to manage and coordinate design and construction activities and also improve the feasibility of the draft. CM doesn't conclude any contract with the designers and contractors. The own constructional work is performed by several specialized contractors who carry out one or more "work packages". These contractors have a direct contract with the owner.

Advantages:

- CM becomes a full member of the project team; he is able to contribute to the feasibility of the design by his experience
- It removes the disagreement between the designers and the contractors and improves the level of communication
- Decisions of the selection of subcontractors are taken together by the owner, designer and CM, this ensures better quality of selection
- Design changes without the necessary price increase can be made much longer than by other delivery method
- The overall construction can be shortened because of *fast-tracking*

Disadvantages:

- It requires a well-informed and experienced client
- The owner must have a quality team that constantly monitors the flow of the information and timetable
- The owner must be able to formulate and communicate his vision for the project
- The owner has only approximate cost of the project, he does not know the total cost till the last moment of completion of the subcontract

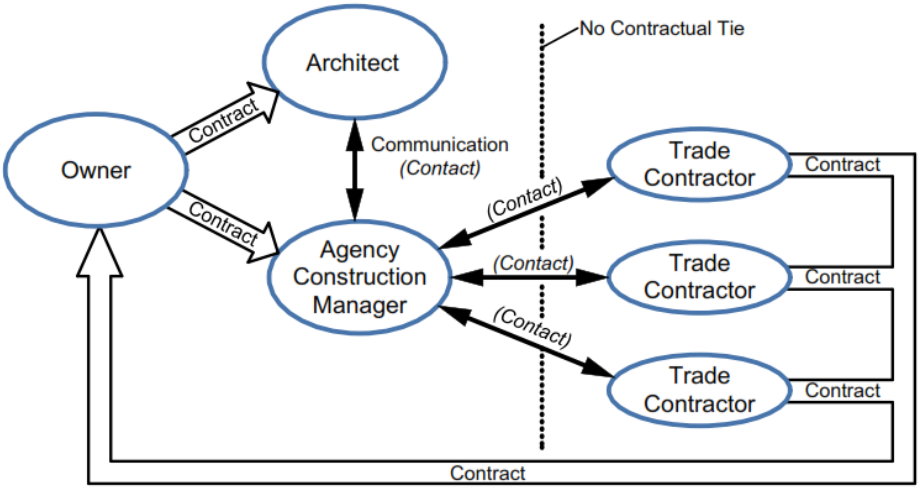

Figure 7: PROFESSIONAL CONSTRUCTION MANAGEMENT (Source: Lecture Industry overview)

Contractor strategy	INDICATIVE RISK ALLOCATION	
	Client	Contractor
Private Finance (NPD model)		
Design and Construct		
Prime Contracting		
Traditional		
Framework Agreements		
Management Contracting		
Construction Management		

Figure 8: RISK ALLOCATION ACCORDING TO CONTRACTS (Source: CWPG 2005)

2.4. TYPES OF CONTRACTS

Contract is an agreement between two or more parties. Especially in the construction industry it is a very big deal because there we are talking about very large projects with high costs. Everyone is interested in the price; therefore it is important that both sides agree on it. The dealing with the claim, which certainly will be, depends on how well the contract will be prepared.

Which form of the contract is used depends upon the type of project and the amount of risk that the owner is willing to accept.

There are four basic types of construction contracts:

- Lump sum contract
- Cost-plus-fee contract
- Guaranteed maximum price contract
- Unit cost contract

2.4.1. LUMP SUM CONTRACT

This type of the contract is the most common in the construction industry. This contract is very profitable for the owner since it is fixed amount of money; the owner knows the costs from the beginning. From the owner's standpoint, regarding the price it is good for him because by this contract he transfer the risks to the contractor. The contractor is responsible for the completion of the works within agreed scope and time; the contractor is led to savings, but this may be used against the owner because of substandard materials and works.

It is used for contracts where the scope can be clearly described in advance, primarily for buildings. For construction orders which cannot be accurately determined in advance, the lump sum contract is inappropriate.

2.4.2. COST PLUS FEE CONTRACT

The contracts based on cost price include basic variable amount fixed pursuant the actual cost and fixed or variable amount referred as fee. This type of contract is often used in

situations where it is difficult to define the scope of the project or when time is of the essence and construction needs to start before the full plans are complete.

This contract is more profitable for the contractor, because he has a guaranteed profit on the job regardless of project cost. The owner does not know the final costs until the moment of completion of the work.

It must be clear on what basis the fee is determined. There are many ways to identify it.

The fee can be defined for example as:

- Fixed amount (= cost plus fixed fee contract)
- Fixed percentage of total costs (= cost plus fixed percentage of cost contract)
- Variable percentage of total cost (= cost plus variable percentage of cost contract)

2.4.3. GUARANTEED MAXIMUM PRICE CONTRACT

This type of contract contains the best features of the lump sum and cost plus fee contracts. The owner is protected by the guarantee of maximum price and receives the benefit of any realized savings; any costs over this limit are up to the contractor.

Mostly the owner provides an incentive to the contractor for working as efficiently as possible by agreeing to split any savings with the contractor. That warrants to the owner well performing contractor.

2.4.4. UNIT PRICE CONTRACT

This type of contract is used when the work cannot accurately be measured ahead of time; unit pricing is common for heavy civil and highway type projects. Actual amount paid to the contractor depends on the actual quantity of each executed item; in the contract there are inscribe unit prices of each item of the work; the final price is not known until the work is complete.

3. PROJECT STAKEHOLDER MANAGEMENT

Every construction project has stakeholders who can impact the project. It is necessary to know with whom we have the honour and how we can communicate with them.

In the project stakeholder management there are few processes[18]:

- Stakeholders identification
- Planning stakeholder management
- Managing stakeholder engagement
- Stakeholder engagement control

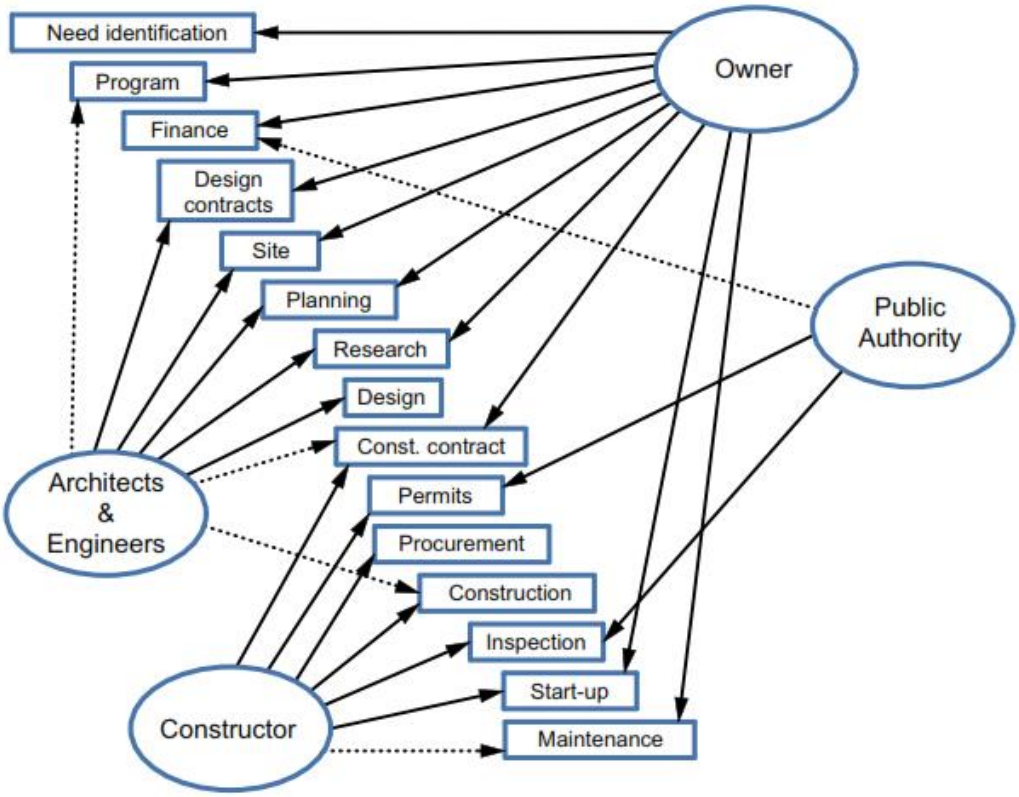

FIGURE Steps in the project delivery process. The figure shows traditional responsibilities. These responsibilities change under different project delivery systems. Note that most of the steps involve more than one party. These joint responsibilities are usually described in contract documents. The dashed lines indicate optional duties. The design team may help prepare the program, and a public authority may float bonds to finance a project. An architect usually administers a construction contract as agent to the owner. A constructor may perform mainenance under separate contract. Project delivery systems seek to tailor the process and the relationships among the parties to the best advanrage of the owner.

Figure 9: EXAMPLE OF STAKEHOLDERS INVOLVEMENT DURING THE WHOLE LIFE CYCLE (Source: Lecture Industry overview)

[18] *A guide to the project management body of knowledge (PMBOK guide)*, p. 391.

3.1. STAKEHOLDERS IDENTIFICATION

Identification of the stakeholders is one of the key processes of the successful project management. The stakeholders are the people, groups or organizations that could affect the project; including all members of the project team as well as all interested parties, internal or external to the organization.

Important thing for the project to be successful is to identify the stakeholders early in the project and to analyse their levels of interest, importance or influence. The project team must to identify the internal and external, positive and negative stakeholders to determine the requirements and expectations of all entities involved in the project. Managing of the stakeholder's influences is significant to the project success.[19]

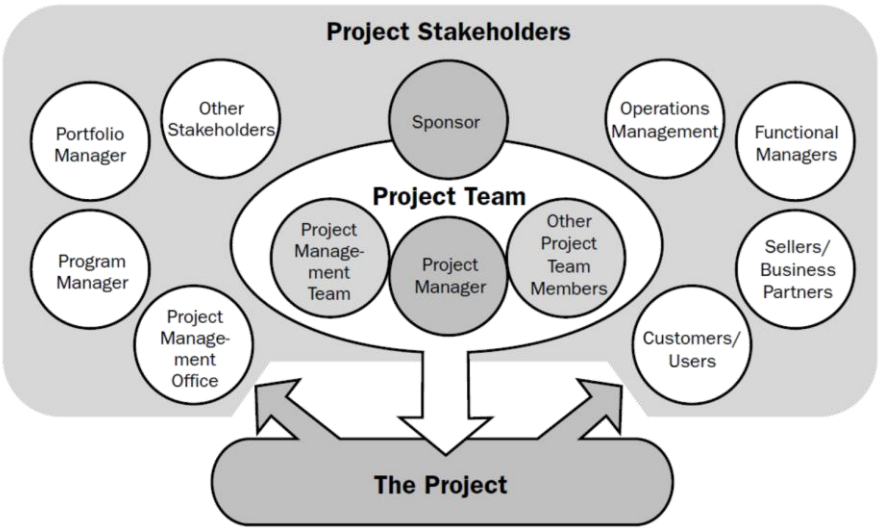

Figure 10: THE RELATIONS BETWEEN STAKEHOLDERS IN THE PROJECT (Source: PMBOK)

The stakeholders have varying levels of responsibility and authority; they require the project manager's attention throughout the project life cycle. Important part is to manage stakeholder expectations that could be difficult due to very different and conflicting objectives.

3.1.1. INPUTS

The inputs of stakeholder identification are as follows[20]:

[19] *A guide to the project management body of knowledge (PMBOK guide)*, p. 391-398.

[20] *A guide to the project management body of knowledge (PMBOK guide)*, p. 394-395.

Project charter

- Information about internal and external entities related with the project

Procurement documents

- Description of the desired form of the response, the relevant procurement statement of work and any required contractual provisions

Enterprise environmental factors

- Conditions not under control of the project team as: organizational culture and structure; government or industry standards; global, regional or local trends and habits

Organizational process assets

- Plans, processes, procedures and knowledge as: stakeholder register templates; lessons learned from previous projects or phases; stakeholder registers from previous projects

3.1.2. TOOLS & TECHNIQUES

The tools and techniques of stakeholder identification are as follows[21]:

Stakeholder analysis

It is a systematic gathering and analysing qualitative and quantitative information to determine interests, expectations and influences related to the project.

There are three steps of stakeholder analysis:

- Identification of all potential project stakeholders and relevant information, such as their roles, interests, knowledge, expectations, influence levels
- Analysing of the potential impact of each stakeholder and defining of the approach strategy
- Assessment of the reaction of the key stakeholder and planning their influence to mitigate potential negative impacts

Classification models of the stakeholder analysis as: Power / interest grid; power / influence grid; influence / impact grid; salience model

[21] *A guide to the project management body of knowledge (PMBOK guide)*, p. 395-398.

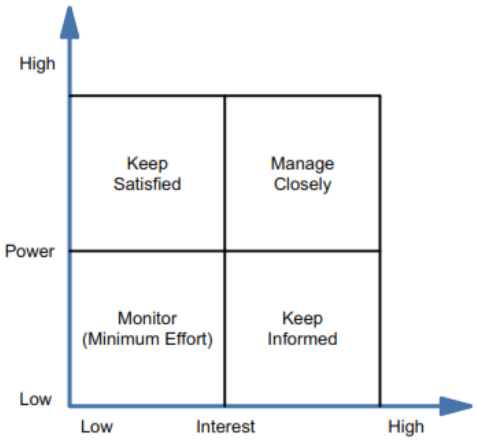

Figure 11: POWER / INTEREST GRID WITH STAKEHOLDERS (Source: Leadership & Project Management Champions)

Expert judgment

- That is knowledge and opinions of individuals or groups with particular expertise, such as: senior management, identified key stakeholders, industry groups and consultants, project managers working on the similar projects

Meetings

- Sessions of stakeholders leading to the exchange and analysing of information about roles, interests, knowledge of each stakeholder

3.1.3. OUTPUTS

The main output of the stakeholder identification is the stakeholder register in which are details about identified parties.

Stakeholder register

- Identification information
  - Name, organizational position, role in the project
- Assessment information
  - Major requirements and expectations, potential influence
- Stakeholder classification
  - Internal or external, supporter or neutral or resistor

Stakeholder register should be control and update due to changes throughout the life cycle.[22]

[22] *A guide to the project management body of knowledge (PMBOK guide)*, p. 398.

3.2. PLANNING STAKEHOLDER MANAGEMENT

The process of developing strategies to effectively engage stakeholders throughout the project life cycle is based on the analysis of stakeholder's needs, interests and potential impact on the success of the project. The plan stakeholder management identifies how the project will affect stakeholders.[23]

3.2.1. INPUTS

The inputs of planning stakeholder management are as follows[24]:

Project management plan

- Information such as: project life cycle; description of works, description of labor; information about changes; techniques of communication

Stakeholder register

- Details of project's stakeholders and their roles

Enterprise environmental factors

- Conditions not under control of the project team as: organizational culture and structure; government or industry standards; global, regional or local trends and habits

Organizational process assets

- Plans, processes, procedures and knowledge as: stakeholder register templates; lessons learned from previous projects or phases; stakeholder registers from previous projects

3.2.2. TOOLS & TECHNIQUES

The tools and techniques of planning stakeholder management are as follows[25]:

[23] *A guide to the project management body of knowledge (PMBOK guide)*, p. 399-404.

[24] *A guide to the project management body of knowledge (PMBOK guide)*, p. 400-401.

[25] *A guide to the project management body of knowledge (PMBOK guide)*, p. 401-403.

Expert judgment

- See 3.1.2.

Meetings

- See 3.1.2.

Analytical techniques

- The comparison of the current and the planned engagement levels of all stakeholders
- Engagement levels
  - Unaware
  - Resistant
  - Neutral
  - Supportive
  - Leading

The engagement can be documented in Stakeholders engagement assessment matrix.

3.2.3. OUTPUTS

There are two main outputs of the planning stakeholder management[26]:

Stakeholder management plan

- Part of the project management plan; formal or informal, highly detailed or broadly framed identification of the management strategies
- Providing of: engagement levels of key stakeholders; scope and impact of change to stakeholders; identification of interrelationships between stakeholders; stakeholder communication requirements; time frame and frequency for the distribution of required information; method for updating and refining the stakeholder management plan

Project documents updates

- Updating of: project schedule; stakeholder register

[26] *A guide to the project management body of knowledge (PMBOK guide)*, p. 403-404.

3.3. MANAGING STAKEHOLDER ENGAGEMENT

This process is how to communicate and work with stakeholder throughout the project life cycle. Managing stakeholder engagement ensures that stakeholders clearly understand the project goals, objectives and risks; it is important to increase the probability of the success of the project. The project manager engages and manages the various stakeholders in a project to decreasing of the project risks.[27]

3.3.1. INPUTS

The inputs of managing stakeholder engagement are as follows[28]:

Stakeholder management plan

- See 3.2.3.

Communications management plan

- Component of the project management plan; description of the project communication (plan, structure, monitoring, control)
- Including information as: stakeholder communications requirements; language, format, content, level of details; reason for distribution of information; person or groups receiving information; escalation process

Change log

- Documentation of the changes occurring during a project

Organizational process assets

- See 3.2.1.

3.3.2. TOOLS & TECHNIQUES

The tools and techniques of managing stakeholder engagement are as follows[29]:

[27] *A guide to the project management body of knowledge (PMBOK guide)*, p. 404-409.

[28] *A guide to the project management body of knowledge (PMBOK guide)*, p. 406-407.

[29] *A guide to the project management body of knowledge (PMBOK guide)*, p. 407-408.

Communication methods

This is the methods how to share information among project stakeholders

There are three methods:

- Interactive communication – the most efficient way; multidirectional exchange of information as: meetings, phone calls, video conferences
- Push communication – transmission to specific recipients as: letters, memos, reports, emails, press releases
- Pull communication – transmission to large audiences as: intranet sites, e-learning, lessons learned databases, knowledge repositories

Interpersonal skills

- The project manager's own skills how to manage stakeholder's expectations as: building trust; resolving conflict; active listening; overcoming resistance to change

Management skills

- The project manager's management skills how to coordinate and harmonize the group as: facilitation of consensus toward project objectives; influencing people to support the project; negotiating agreements to satisfy the project needs; modifying organizational behaviour to accept the project outcomes

3.3.3. OUTPUTS

There are main outputs of the managing stakeholder engagement[30]:

Issue log

- Documentation of the issues occurring during a project

Change requests

- Requests for the changes of the product or the project, including corrective or preventive actions

Project management plan updates

- Updating of the project management plan due to: no longer needs of some communications; changes of communication method

[30] *A guide to the project management body of knowledge (PMBOK guide)*, p. 408-409.

Project documents updates

- Updating of: stakeholder register

Organizational process assets updates

- Updating of: stakeholder notifications; project reports; project presentations; project records; feedback from stakeholders; lessons learned documentation

3.4. STAKEHOLDER ENGAGEMENT CONTROL

Stakeholder engagement activities are executed during the project life cycle; stakeholder engagement should be continuously controlled to increase its efficiency and effectiveness.[31]

3.4.1. INPUTS

The inputs of stakeholder engagement control are as follows:[32]

Project management plan

- Information such as: project life cycle; description of works, description of labor; information about changes; techniques of communication

Issue log

- Documentation of the issues occurring during a project

Work performance data

- The observations and measurements identifying during the project works as: key performance indicators; technical performance measures; start and finish dates of schedule activities; number of change requests; number of defects; actual costs; actual durations

Project documents

- Documentation as: project schedule; stakeholder register; issue log; change log; project communications

[31] *A guide to the project management body of knowledge (PMBOK guide)*, p. 409-415.

[32] *A guide to the project management body of knowledge (PMBOK guide)*, p. 411-412.

3.4.2. TOOLS & TECHNIQUES

The tools and techniques of stakeholder engagement control are as follows:[33]

Information management systems

- Standard tool of capturing, storing and distributing information to stakeholders as: table reporting; spreadsheet analysis; presentations

Expert judgement

- See 3.1.2.

Meetings

- Sessions of stakeholders about their engagement

3.4.3. OUTPUTS

There are two main outputs of the stakeholder engagement control[34]:

Work performance information

- Performance data as: status of deliverables; implementation status for change requests; forecasted estimates to complete

Change requests

- Requests for the changes of the product or the project, including corrective or preventive actions

Project management updates

- Updating of: change management plan; communications management plan; cost management plan; HR management plan; procurement management plan; quality management plan; requirements management plan; risk management plan; schedule management plan; scope management plan; stakeholder management plan

Project documents updates

- Updating of: stakeholder register; issue log;

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[33] *A guide to the project management body of knowledge (PMBOK guide)*, p. 412-413.

[34] *A guide to the project management body of knowledge (PMBOK guide)*, p. 413-415.

Organizational process assets updates

- Updating of: stakeholder notifications; project reports; project presentations; project records; feedback from stakeholders; lessons learned documentation

The identification of stakeholders and the right way of communications with them during the whole project life cycle are one of the keys to the risk management.

4. RISK MANAGEMENT

At the start of any project, there is a large amount of risks. The objectives of project risk management are to increase the probability and impact of positive events and decrease the probability and impact of negative events in the project. Risk management is a systematic repetitive set of interrelated activities aiming to manage the potential risks.[35]

The risk management we can divide into six processes:

- Planning risk management
- Risk identification
- Qualitative risk analysis
- Quantitative risk analysis
- Risk responses
- Risk control

4.1. PLANNING RISK MANAGEMENT

The planning risk management defines how to conduct risk management activities. It is necessary that the risk management processes are agreed and supported by all stakeholders; that leads to effective performance during the whole project life cycle.

Planning is important to provide sufficient resources and time to manage the risks. The plan should begin with start of a project.[36]

4.1.1. INPUTS

The main inputs of the risk management plan are information about the project which will be assessed, project management plan – information about all areas that could be risk-affected such as: scope, schedule and cost.

Other important inputs contain details about identified stakeholders such as stakeholder register; and information about the organization such as organizational process assets and enterprise environmental factors.[37]

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[35] *A guide to the project management body of knowledge (PMBOK guide)*, p. 309.

[36] *A guide to the project management body of knowledge (PMBOK guide)*, p. 313-318.

[37] *A guide to the project management body of knowledge (PMBOK guide)*, p. 314-315.

Organizational process assets

- Plans, processes, procedures and knowledge as: risk categories common definitions of concepts and terms; risk statement formats; standard templates; roles and responsibilities; authority levels for decision making; lessons learned

Enterprise environmental factors

- Conditions not under control of the project team as: organizational culture and structure; government or industry standards; global, regional or local trends and habits

4.1.2. TOOLS & TECHNIQUES

The tools and techniques of planning risk management are as follows:[38]

Analytical techniques

- Procedures leading to understanding and defining the risk management as: risk profile analysis; using of the strategic risk scoring sheets

Expert judgment

- Knowledge and opinions of individuals or groups with particular expertise, such as: senior management, identified key stakeholders, industry groups and consultants, project managers working on the similar projects

Meetings

- Sessions of stakeholders leading to defining risk management activities

4.1.3. OUTPUTS

The main output is **risk management plan**. The risk management plan is a part of the project management plan and defines the structure and performance of the risk management.

The risk management plan provides methodology, roles and responsibilities, budgeting, timing, risk categories, definitions of risk probability and impact, probability and impact matrix, revised stakeholders' tolerances, reporting formats or tracking.[39]

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[38] *A guide to the project management body of knowledge (PMBOK guide)*, p. 315-316.

4.2. RISKS IDENTIFICATION

The identification of the risks is the main process of the risk management. It is necessary to know which risks we face. Risk identification determines what might happen that could affect the objectives of the project and how those things might happen. The process should be structured using the key elements to examine risks systematically, in each area of the project to be addressed.

Valid information is important in identifying risks and in understanding the likelihood and the consequences of each risk. As the project progresses through its life cycle the new risks could develop, therefore there is a need of iteration of identifying the risks. [40]

4.2.1. INPUTS

The inputs of risk identification are information from all areas which could be affected by risks, especially information about the project including details about stakeholders but also information about internal company's activities, tools and techniques, already realized projects and also information about external conditions such as technical standards, laws, political situation, climatic conditions etc.

Below there are indicated inputs:[41]

Risk management plan

- See 4.1.3.

Cost management plan

Schedule management plan

Quality management plan

Human resource management plan

Scope baseline

- Approved version of scope statement, work breakdown structure and work breakdown structure dictionary

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[39] *A guide to the project management body of knowledge (PMBOK guide)*, p. 316-318.

[40] *A guide to the project management body of knowledge (PMBOK guide)*, p. 319-321.

[41] *A guide to the project management body of knowledge (PMBOK guide)*, p. 321-324.

Activity cost estimates

- Quantitative assessments of the probable costs

Activity duration estimates

- Quantitative assessments of the likely number of time period

Stakeholder register

- Details of project's stakeholders and their roles

Project documents

- Documentation as: project charter; project schedule; schedule network diagrams; issue log; quality checklist; other information proven to be valuable in identifying risks

Procurement documents

- Description of the desired form of the response, the relevant procurement statement of work and any required contractual provisions

Enterprise environmental factors

- Conditions not under control of the project team as: published information, including commercial databases; academic studies; published checklists; benchmarking; industry studies; risk attitudes

Organizational process assets

- Plans, processes, procedures and knowledge as: project files, including actual data; organizational and project process controls; risk statement formats or templates; lessons learned

4.2.2. TOOLS & TECHNIQUES

The project manager or risk manager should be able to put yourself into situation of all stakeholders to understand all the connections. He or she should be able to predict a wide range of risks but the main goal is to find real risks not absurd.

The perception of risk is subjective, everybody perceives risks differently; therefore it is necessary to specify the procedures how the risks will be identified and assessed. The process of identifying risks should be systematic to prevent skipping or oblivion of the important risks.

The tools and techniques of risk identification are as follows:[42,43]

Documentation reviews

- Structured review of the plans, assumptions, previous project files, agreements

Diagramming techniques

Cause and effect diagrams

The diagram illustrates the main causes and sub causes leading to an effect. It is used to identify potential root causes to problems.

The diagram is also called as Ishikawa fishbone diagram.

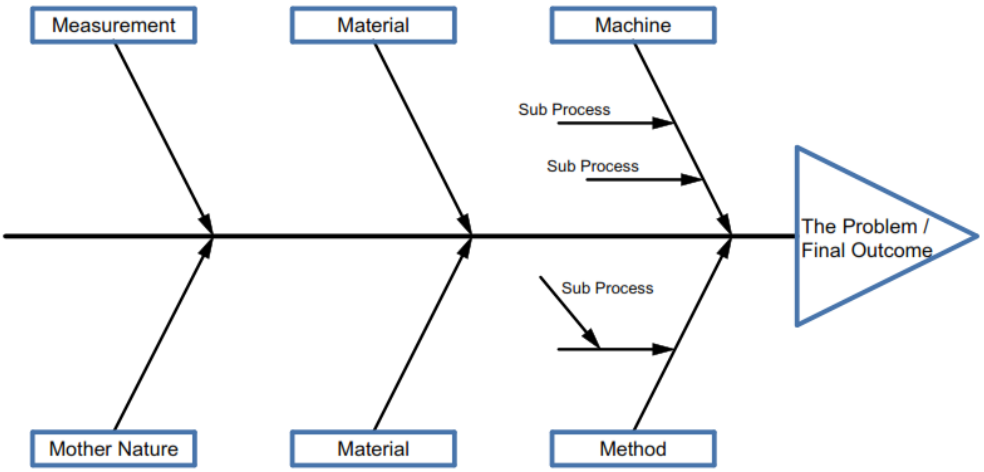

Figure 12: CAUSE AND EFFECT DIAGRAM (Source: Creately)

System of process flow charts

This technique can be used to analyse an entire process by following the logical steps leading an objective. Flow charts are acclaimed for their ability to identify bottlenecks and superfluous processes.

Influence diagrams

This is a technique of graphical representations of situations showing causal influences among variables and outcomes. Influence diagrams show how risks influence one another.

[42] *A guide to the project management body of knowledge (PMBOK guide)*, p. 324-327.

[43] TICHÝ, Milík. *Ovládání rizika*, p. 180-189.

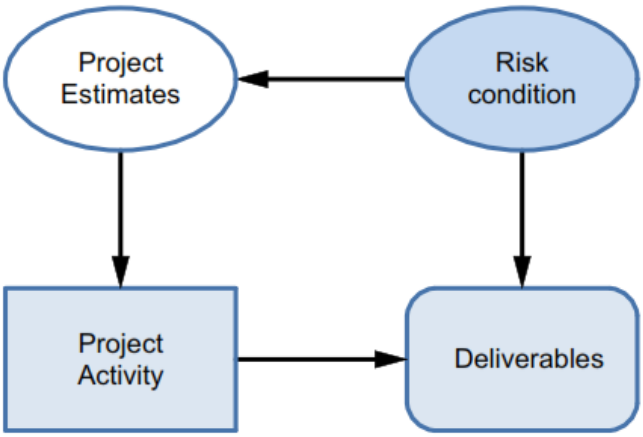

Figure 13: INFLUENCE DIAGRAM (Source: PMBOK)

Information gathering techniques

Brainstorming

This is a simple and quick method of generating ideas. It is a session of project team in which they come up with their thoughts. Participants interact with each other and come up with new ideas which would not occur without stimulus. During the brainstorming there are said thoughts which would be otherwise suppressed by shyness or feeling of inferiority.

Delphi technique

This method is based on the anonymous questioning of experts, independently of each other; on their particular point of view. The responses are summarized and returned to the participants for further remark; this process can be repeated several times until they will come to the similar conclusion.

Interviewing

This method is very common; based on conversation between project participants, stakeholders and risk experts.

Root cause analysis

It is a method of problem solving by identifying the underlying causes leading to the whole problem and developing the prevention. This technique uses Ishikawa Fishbone diagram.

Assumptions analysis

This method identifies risks to the project from inaccuracy, instability, inconsistency or incompleteness of assumptions. The risks are directly proportional to the consequences or the impacts to the project objectives if the assumption turns out to be wrong.

SWOT analysis

This is a structured method used to evaluate the strengths, weaknesses, opportunities and threats. The goal of this analysis is to gain an overview how reduce threats and how increase the likelihood of opportunities.

Checklist analysis

This method is quick and simple; usually based on some good practice and experience by which is created. It can be used by team members who have relatively less experience in similar projects. This method should be used at the end of the risk identification to ascertain that there has been explored all likely areas of risks.

4.2.3. OUTPUTS

The goal is to identify risks and these risks are summarized in the Risk register. Risk register is document that contains the outcomes of risk management processes. At this stage of risk management the risk register contains list of identified risks and also the list of potential responses.

Risk register

- List of identified risks
  - This document comprises determined risks in such details as it is possible.
- List of potential responses
  - This document contains the potential responses to the identified risks. These actual responses will be finalized during the Plan risk responses process.

The risk register will be updated and supplemented by additional information during the next risk management processes.

4.3. QUALITATIVE RISK ANALYSIS

Risk qualification is the process of distinction of the identified risks; because not every risk has the same impact on the project. The main goal is to reduce the level of uncertainty and to focus on high-priority risks.

Qualitative analysis uses words to describe the extent of potential consequences and the likelihood that these consequences occur. This analysis is usually performed when there is a need to quickly assess and identify the biggest risks; this performance demands lower requirements of the range of inputs and financial resources.

Usually, this analysis is followed by quantitative analysis to clearly evaluate the consequences of the risks.[44]

4.3.1. INPUTS

The main input is the risk register where are listed the all known risks. Other inputs are the further information about the project, the company and the external conditions.

Inputs to qualitative assessment are below:[45]

Risk register

- Document of identified risks

Risk management plan

- See 4.1.3.

Scope baseline

- Approved version of scope statement, work breakdown structure and work breakdown structure dictionary

Enterprise environmental factors

- Conditions not under control of the project team as: published information, including commercial databases; academic studies; published checklists; benchmarking; industry studies; risk attitudes

Organizational process assets

- Plans, processes, procedures and knowledge as: project files, including actual data; organizational and project process controls; risk statement formats or templates; lessons learned

[44] *A guide to the project management body of knowledge (PMBOK guide)*, p. 328-329.

[45] *A guide to the project management body of knowledge (PMBOK guide)*, p. 329-330.

4.3.2. TOOLS & TECHNIQUES

The tools and techniques of qualitative risk analysis are as follows:[46]

Risk categorization

This technique of the grouping of the risks helps to effective risk responses. The criterion of the classification is primarily the source of the risk, but also area impacted or project phase.

Risk probability and impact assessment

This method analyse the likelihood of the risks which could occur; and their potential effects on a project. Each identified risk is assessed.

Risk Probability describes the potential for the risk event occurring. The probability of a risk occurring can range anywhere between 0% and 100%.

- **Remote (Very low)**
  - Risk is extremely unlikely to occur. 0-20%
- **Unlikely (Low)**
  - Risk is unlikely to occur. 21-40%
- **Occasional (Medium)**
  - There is a possible chance that the risk will occur. 41-60%
- **Likely (High)**
  - It is highly likely that the risk will occur. 61-80%
- **Definitely (Very high)**
  - It is almost a certainty that the risk will occur. 81-100%

Risk impact describes the effects or consequences the project will experience if the risk event occurs. The impact may be in terms of money, time, organization's reputation, loss of business, injury to people, damage to property and so on. Categories of impact are:

- **Insignificant (Very low)**
  - Risks which do not pose any significant threat and which can be left unmediated without any fear.
- **Marginal (Low)**
  - Any risks which will have just a mild impact on the project, still these must be addressed in time.

[46] *A guide to the project management body of knowledge (PMBOK guide)*, p. 330-333.

- **Moderate**
  - Risks which will cause some problems, but nothing too significant.
- **Critical (High)**
  - Risks which can significantly jeopardize some aspects of the project, but which will not completely ruin the project.
- **Catastrophic (Very high)**
  - A risk that can prove detrimental for the whole project.

Defined Conditions for Impact Scales of a Risk on Major Project Objectives
(Examples are shown for negative impacts only)

Project Objective	Relative or numerical scales are shown				
	Very low /0.05	Low /0.10	Moderate /0.20	High /0.40	Very high /0.80
Cost	Insignificant cost increase	< 10% cost increase	10 – 20% cost increase	20 – 40% cost increase	> 40% cost increase
Time	Insignificant time increase	< 5% time increase	5 – 10% time increase	10 – 20% time increase	> 20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

Figure 14: DEFINITION OF IMPACT SCALES FOR FOUR PROJECT OBJECTIVES (Source: PMBOK)

Probability and impact matrix

The probability and impact matrix (tabular risk map) is a graphical construction used to display risk severity; the tables are used with different detailed breakdown. The matrix generally used is a 3x3 matrix or 5x5 matrix. Probability and Impact Matrix uses the combination of probability and impact scores of individual risks and ranks/ prioritizes them for easy handling of the risks. The probability and impact matrix helps to determine which risks need detailed risk response plans. It is vital to understand the priority for each risk as it allows the project team to appreciate the relative importance of each risk.[47,48]

[47] *A guide to the project management body of knowledge (PMBOK guide)*, p. 331-332.

[48] TICHÝ, Milík. *Ovládání rizika*, p. 192-195.

Each of the cells on the 5x5 matrix has been given one of the four colours – green, yellow, orange and red. The significance of these colours is:

- **Green (Low Risk)**

The risks in the green are nearly harmless and in most cases these risks can be safely ignored. Most risks in this category don't require any mediation at all.

- **Yellow (Moderate Risk)**

These are risks which can be left out during the formulation of risk management strategies, as these are low priority risks and can be handled as and when they arise. However, that does not mean these risks can be ignored altogether.

- **Orange (High Risk)**

These are the risks that again must be optimally addressed; however they do not enjoy top priority like the risks in red cells. These are also significant risks and it's advisable to have them included in the risk management strategies.

- **Red (Extreme Risk)**

All risks that fall in the red cells are of utmost importance. Prevention and mitigation strategies for all these risks must be framed much in advance so as to prevent their occurrence or to fight them back as soon as they surface up.

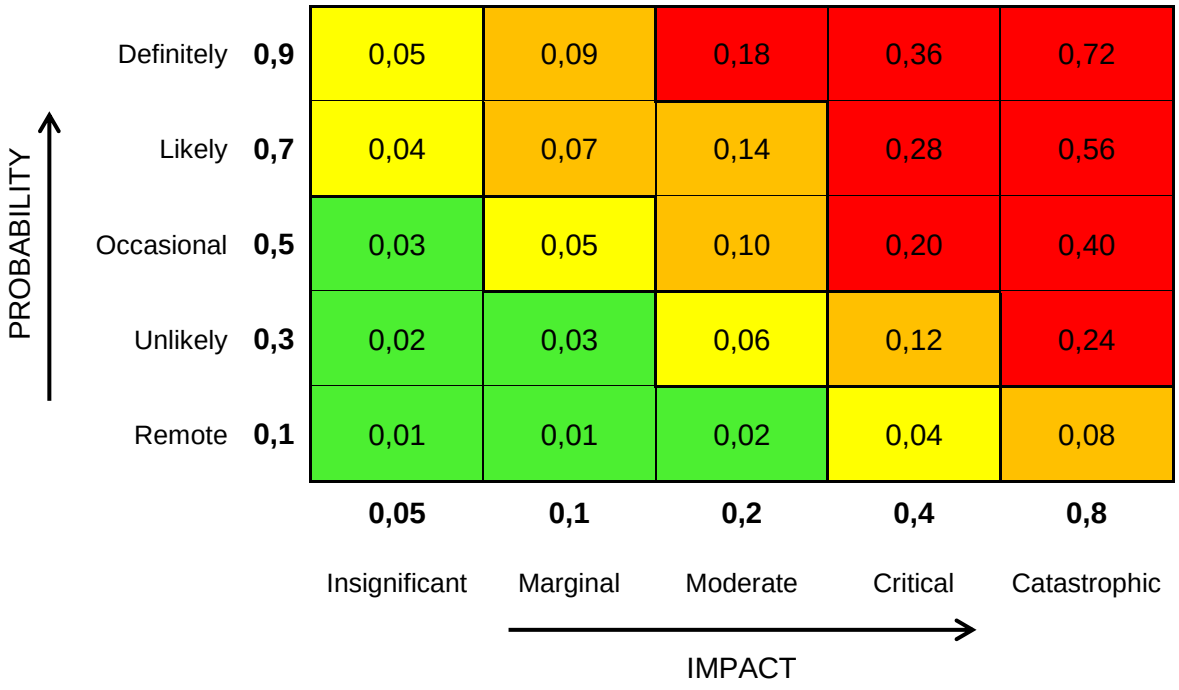

Figure 15: RISK MATRIX (Source: author)

Risk data quality assessment

This is a method to evaluate the quality of the basic data, the reliability and accuracy of the information from which the risk rating is derived.

Risk urgency assessment

The purpose of this risk urgency assessment technique is to identify near term risks which have a higher level of urgency than some risks in future. It is necessary to try to identify those risks that require our immediate attention.

4.3.3. OUTPUTS

The main output of the qualitative assessment is **Updated risk register**.

By the qualitative analysis the risks are grouped into categories; it helps to reveal areas of risk concentration and highlight the common causes of risk. An overall picture of the number of risks in each category helps to the project manager to prioritize the group with the most number of extreme or high risks.

In the risk register updates there are also stated probability and impacts for each risk. By the rating the risk scores and using the probability and impact matrix the project manager will get the level of importance of risk; based on that he or she will be able to focus on the prioritized objectives.

By sorting according to urgency, the project manager will get the list of risks requiring almost immediate reaction or vice versa that can be handled later.

Some risks require further analysis to know the exact impact, especially those with high priority.[49]

4.4. QUANTITATIVE RISK ANALYSIS

Risk quantification is a further analysis of the risk management; it is the process of the numerical evaluation of the identified risks. The main goal is to estimate the frequency and the severity of losses endangering the project and prioritize the risks by their cost.

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[49] *A guide to the project management body of knowledge (PMBOK guide)*, p. 333.

Based on the detailed examination of the risks the project manager gets the information for the decision making about those risks.[50]

4.4.1. INPUTS

The main input is the updated risk register where are listed the all known risks with their probability and impact. Other inputs are the further information about the project, the company and the external conditions.

The inputs to the quantitative risk analysis are:[51]

Risk register

- Document of identified risks including information from the qualitative analysis

Risk management plan

Cost management plan

Schedule management plan

Enterprise environmental factors

Organizational process assets

4.4.2. TOOLS & TECHNIQUES

The quantitative methods of risk assessment can be grouped into analytic and empirical approaches. The empirical estimate is based on the knowledge and experience from the finished projects. The analytic estimate is based on the mathematical models and probabilistic methods.[52]

Analytic estimate

This method is based on the mathematical model that calculates the probability of occurrence of examined case.

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[50] *A guide to the project management body of knowledge (PMBOK guide)*, p. 333-335.

[51] *A guide to the project management body of knowledge (PMBOK guide)*, p. 335-336.

[52] TICHÝ, Milík. *Ovládání rizika*, p. 60-63, 151-161.

There are two assessments:

- Aprioristic
  - It is based on random behaviour of the similar case; on data from past observations.
- Aposterioristic
  - It is based on random behaviour of the partial object of the similar case; on mathematical models and observation data.[53]

In that approach there are three steps:

- Determination of the statistical parameter
- Selection of the probability distributions
- Calculation of the searched value

Expected monetary value analysis

This is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen. Opportunities are positive values, threats negative.

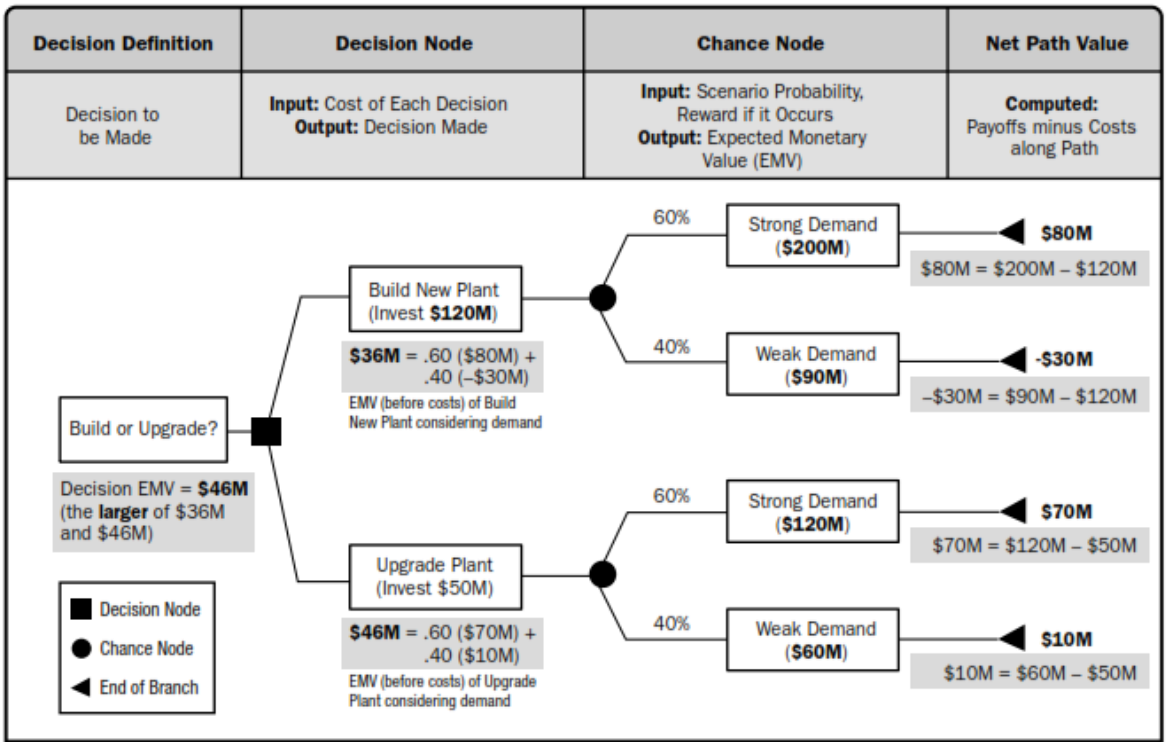

Figure 16: EXPECTED MONETARY VALUE ANALYSIS (Source: PMBOK)

[53] TICHÝ, Milík. *Ovládání rizika*, p. 60-63, 151-161.

Fault tree analysis (FTA)

The main goal of this analysis is to estimate hypothetical failure that may occur by the risks and to find their causes.

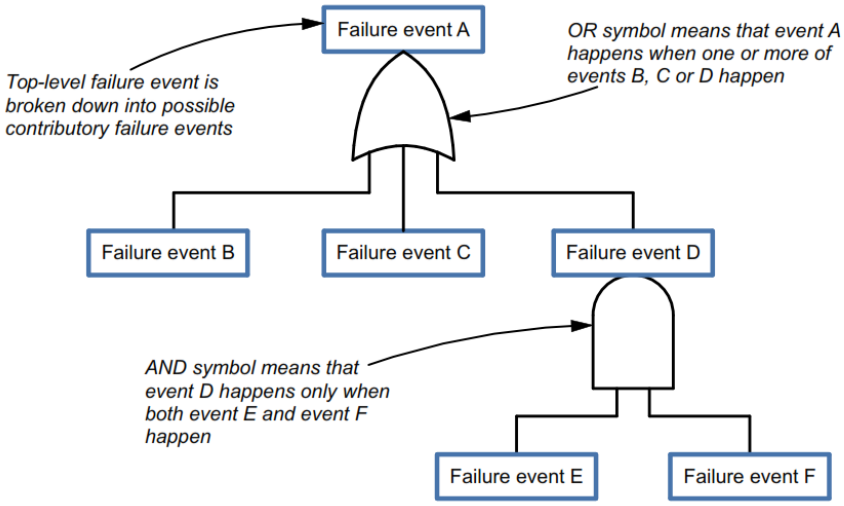

Figure 17: FAULT TREE ANALYSIS (Source: Syque)

Event tree analysis (ETA)

This analysis is used to evaluate the process and the events leading to the possible accident.

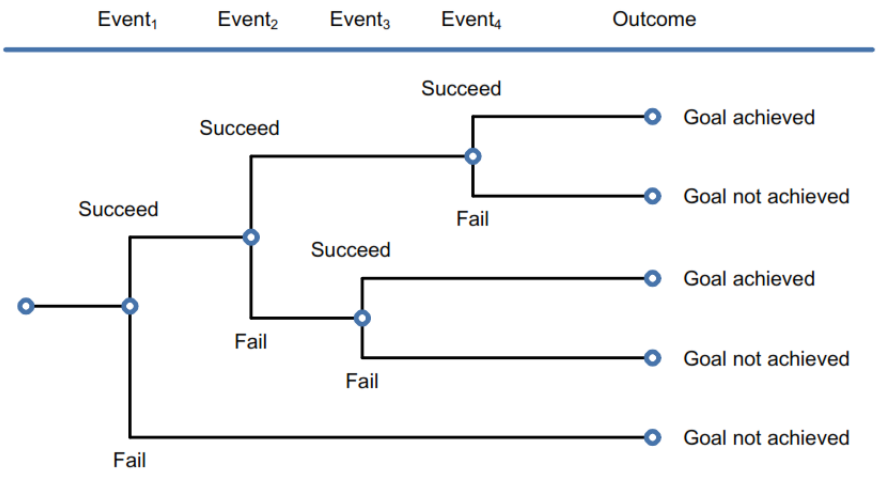

Figure 18: EVENT TREE ANALYSIS (Source: Oak Ridge National Laboratory)

Monte Carlo simulation

The Monte Carlo technique is a method of simulation using a random number generator. This technique requires the selection of different values from a probability distribution, the

values corresponding to their probability of occurrence. The quantitative risk is usually included in the risk model by estimating a pessimistic, a normal and an optimistic value, known as a triangular distribution. The project model is computed multiple times; the analysis uses randomly chosen input values for each iterant action.

Empirical estimate

This approach is based on the experiences of the project team from past events and projects or on the general experiences.

In this method there are distinguished two parameters; financial, expressed by the monetary value of the damage, and social, expressed by the damage to the health or of human life.[54]

4.4.3. OUTPUTS

The main output of the quantitative assessment is **Updated risk register**.

After the quantitative assessment the risks are estimated and prioritized by their costs. Based on that there are known information for handling project's most threatening risks and promising opportunities.

Prioritizing extreme risks allows one to respond proactively. Monitoring trends enables to adjust risk management activities over time.[55]

4.5. RISK RESPONSES

The plan risk responses is the process of developing the options and the actions. Each risk requires convenient response how to face it; and this process presents approaches to planning those responses.

Risk responses should be appropriate for the importance of the risk, cost-effective in meeting the challenge, realistic within the project context, agreed upon by all stakeholders and owned by a responsible person.[56]

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[54] TICHÝ, Milík. *Ovládání rizika*, p. 60-63, 151-161.

[55] *A guide to the project management body of knowledge (PMBOK guide)*, p. 341.

[56] *A guide to the project management body of knowledge (PMBOK guide)*, p. 342-343.

4.5.1. INPUTS

The main input is the updated risk register where are listed the all known risks with information about them. Other inputs are the further information about the project, the company and the external conditions.[57]

Risk register

The risk register includes identified risks, root causes of risks, lists of potential responses, risk owners, the relative rating or priority list of project risks, etc.

Risk management plan

4.5.2. TOOLS & TECHNIQUES

The risk deciding should be proactive; select procedures earlier than risks arise. Risks can have different effect; therefore it is necessary to choose the right strategy. The strategy should be selected for each risk to be effective.

There are few strategies how to deal with risks. [58,59]

Strategies for negative risks or threats

The negative risks could be handled by:

- Avoidance
- Transference
- Mitigation
- Acceptance

Risk avoidance

This is a strategy of eliminating the threat and protecting the project from its impact. Avoiding a threat means making changes to the project's objectives or achieving them so that the risk can no longer have any effect.

Example of the risk avoidance: extending the schedule, changing the strategy, reducing scope

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[57] *A guide to the project management body of knowledge (PMBOK guide)*, p. 343.

[58] *A guide to the project management body of knowledge (PMBOK guide)*, p. 343-346.

[59] TICHÝ, Milík. *Ovládání rizika*, p. 229-237.

Risk transference

This strategy involves transferring all or part of the impact of the threat to the third party. Another party takes the responsibility of the risk; this party gets paid for the risk assumption.

Example of the risk transference: use of insurance, performance bonds, warranties, guarantees

Some types of contracts ensure that the responsibility of the risk is taken from one party to another, such as cost plus fee contract or lump sum contract.

Risk mitigation

This strategy includes reducing the probability of occurrence or impact of the risk. The risk mitigation can be provided by the prevention, the diversification or the allocation.

The prevention involves proactive prevention – avoiding the risk rise or reactive prevention – being ready for the risk. The diversification is based on remodelling of the risk portfolio. The allocation means assignment of the risk to the stakeholders (specification in the contracts).

Risk acceptance

This is a strategy of taking responsibility of the risk by accepting the consequences. The acceptance of a threat is used where it is not possible or cost-effective way to address the risk.

Strategies for positive risks or opportunities

The positive risks could be handled by:

- Exploit
- Enhance
- Share
- Acceptance

Risk exploit

This strategy is used to ensure that the opportunity is realized.

Risk enhance

This strategy is used to increase the probability or the positive impacts of opportunity by the identification and maximization of key drivers.

Risk share

This strategy of an allocation of the ownership to the third party may be best where the combined skills or financial resources of the partnership are better to realise the opportunity than either may be able to on their own.

Risk acceptance

This is a strategy of the accepting an opportunity.

4.5.3. OUTPUTS

The outputs of plan risk response are updated documents, such as **Project management plan, Risk register**. [60]

4.6. RISK CONTROL

As the project progresses through its life cycle the new risks could develop, therefore there is a need of iteration of risk management processes. The project should be controlled and monitored throughout the whole project life cycle.

The process of the risk controlling improves efficiency of the risk approach throughout the project life cycle.[61]

4.6.1. INPUTS

The main input is the **Risk register** where are listed all known risks with information about them. Other inputs are **Project management plan** with information about the project, company, stakeholders and other conditions; **Work performance data and reports** with information from the performance measurements.[62]

[60] *A guide to the project management body of knowledge (PMBOK guide)*, p. 346-348.

[61] *A guide to the project management body of knowledge (PMBOK guide)*, p. 349.

[62] *A guide to the project management body of knowledge (PMBOK guide)*, p. 350-351.

4.6.2. TOOLS & TECHNIQUES

The tools and techniques of risk control are as follows:[63]

Risk reassessment

The project should be controlled throughout the life cycle; the reassessment usually identifies new risks, revaluate the current risks and close the outdated.

Risk audits

This is a method of examining the effectiveness of risk responses in dealing with known risks and their root causes.

Technical performance measurement

This method is used for being able to compare the plan and the reality which itself may activate triggers.

Reserve analysis

This analysis compares the amount of contingency reserves remaining to the amount of risk remaining at any time in the project.

4.6.3. OUTPUTS

The outputs of risk control are updated documents, such as **Project management plan** with approved changes**, Work performance information or Change requests** with recommended corrective or prevention actions. [64]

[63] *A guide to the project management body of knowledge (PMBOK guide)*, p. 351-352.

[64] *A guide to the project management body of knowledge (PMBOK guide)*, p. 353-354.

5. RISK MANAGEMENT IN REAL CONSTRUCTION PROJECT

This chapter is concentrated on specific projects of hotels. There is risk management applied in practise. The main goals are to analyse the relation and extent of risks in each stage of project life cycle and to compare risks of possibly used delivery methods.

There are two projects, one is the construction project of the hotel building in Prague; the second one is conversion of the House of Trades union services into hotel building. The both hotel projects fall under the world's leading hotel operator for which I worked.

5.1. PROJECT CONTEXT

Bellow there are processes of Project risk management which will be applied on the real construction projects.

- Identification of Stakeholders
- Identification of Risks
- Qualitative risk analysis
- Quantitative risk analysis
- Risk responses
- Risk control

5.1.1. IDENTIFICATION OF STAKEHOLDERS

Identification of the stakeholders is one of the key processes of the successful project management. The stakeholders are the people, groups or organizations that could affect the project; including all members of the project team as well as all interested parties, internal or external to the organization.

5.1.2. IDENTIFICATION OF RISKS

The identification of the risks is the main process of the risk management. It is necessary to know which risks we face. Risk identification determines what might happen that could affect the objectives of the project and how those things might happen.

5.1.3. QUALITATIVE RISK ANALYSIS

Risk qualification is the process of distinction of the identified risks; because not every risk has the same impact on the project. The main goal is to reduce the level of uncertainty and to focus on high-priority risks. Qualitative analysis uses words to describe the extent of potential consequences and the likelihood that these consequences occur.

5.1.4. QUANTITATIVE RISK ANALYSIS

Risk quantification is a further analysis of the risk management; it is the process of the numerical evaluation of the identified risks. The main goal is to estimate the frequency and the severity of losses endangering the project and prioritize the risks by their cost.

5.1.5. RISK RESPONSES

The plan risk responses is the process of developing the options and the actions. Each risk requires convenient response how to face it; and this process presents approaches to planning those responses.

5.1.6. RISK CONTROL

As the project progresses through its life cycle the new risks could develop, therefore there is a need of iteration of risk management processes. The project should be controlled and monitored throughout the whole project life cycle.

5.2. PROJECT NO. 1 – HOTEL CONSTRUCTION

The first construction project on which the risk management will be performed is the construction of the hotel building in Prague, Smíchov. The construction took place in 2004.

The cost of this construction project was 282 million CZK.

5.2.1. IDENTIFICATION OF STAKEHOLDERS

The first step is to identify people, groups, or organizations that could affect the project.

In the table below (Stakeholder register) there are described some stakeholders and their roles in the project.

Table 1: STAKEHOLDER REGISTER

STAKEHOLDER	DESCRIPTION	ROLE IN PROJECT
OWNER	CZECH COMPANY	To manage the financing of the project
	PARENT COMPANY	To specify the technical requirements of the project
PROJECT MANAGEMENT	Building s.r.o.	To provide the control of the project from the owner perspective
FINANCING BANK	UnitCredit Bank Czech Republic, a.s.	To provide the financial support
DESIGN TEAM	AHK architekti	To provide the project documentation and technical supervision
CONTRACTOR COMPANY	Bouygues Batiment	To provide the construction works
CONTRACTOR PROJECT TEAM	Project team Bouygues Batiment	To manage the construction works
SUBCOTRACTORS	Subcontractors of the Construction company	To provide the partial construction works
SUPPLIERS	Suppliers of the Construction company	To provide the material
OPERATOR OF TECHNICAL NETWORKS - WATER	Pražské vodovody a kanalizace, a.s.	To provide the water network
OPERATOR OF TECHNICAL NETWORKS - SEWER SYSTEM	Pražské vodovody a kanalizace, a.s.	To provide the sewer system network
OPERATOR OF TECHNICAL NETWORKS - ELECTRICITY	ČEZ prodej, s.r.o.	To provide the electricity network
OPERATOR OF TECHNICAL NETWORKS - GAS	RWE Energie, a.s.	To provide the heat supply
OPERATOR OF TECHNICAL NETWORKS - ELECTRONIC COMMUNICATIONS	Telefónica O2 Czech Republic, a.s.	To provide the electronic communications network
CONSTRUCTION AUTHORITY	Czech Construction Authority in Prague	To control the regulation compliance
ANTIQUITIES AUTHORITY	Czech Antiquities Authority in Prague	To control the regulation compliance
ENVIRONMENT AUTHORITY	Czech Environment Authority in Prague	To control the regulation compliance
HYGIENE AUTHORITY	Czech Hygiene Authority in Prague	To control the regulation compliance

FIRE PROTECTION AUTHORITY	Czech Fire Protection Authority in Prague	To control the regulation compliance
INFRASTRUCTURE AUTHORITY	Czech Infrastructure Authority in Prague	To control the regulation compliance
SAFETY AUTHORITY	Czech Safety Authority	To control the regulation compliance
OWNERS OF NEIGHBOURING LANDS	Owners of the neighbouring properties	To agree or disagree with the project

5.2.2. IDENTIFICATION OF RISKS

The second step is to identify risks and their impact on the project.

In the following table (Risk register) there are described some risks which can occur during the whole life cycle of the project. For better clarity the risks are categorized into groups according to the phase of the project life cycle.

Abbreviations used in the following table:

D&B = design & build, DBB = design-bid-build, CM = professional construction management / manager

Table 2: RISK REGISTER – RISK IDENTIFICATION

ID	RISK	RISK OWNER			IMPACT
		D&B	DBB	CM	
DESIGN AND BIDDING STAGE					
ENVIRONMENTAL RISKS					
1	Incomplete environmental analysis	contractor	owner	construction manager	Possibility of not issuing of needed permission
2	Environmental regulations change	contractor	owner	construction manager	Possibility of project scope changes, project delay
DESIGN RISKS					
3	Misunderstanding of task	contractor	owner	construction manager	Additional changes in the project
4	Insufficient information about the project	owner	owner	owner	Additional changes in the project
5	Owner involvement in design	owner	owner	owner	Additional changes in the project
6	Problems with design	contractor	owner	construction manager	Project delay
7	Not efficient solution of design	contractor	owner	construction manager	Additional changes in the project, higher costs in later stages
8	Incomplete design	contractor	owner	construction manager	Delay of the start of construction
9	New design standard	contractor	owner	construction manager	Changes in the project documentation, project delay
CONTRACT RISKS					
10	Type of contract	owner	owner	owner	Different responsibility of the risks
11	Contract conditions	owner / contractor	owner / contractor	owner / CM	Limited contract fines, conditions
12	Lack of cooperation between stakeholders	owner	owner	owner / CM	Additional changes in the project

13	Variations in price and foreign exchange	owner / contractor	owner / contractor	owner	Changes in costs
PRE-CONSTRUCTION STAGE					
PROJECT MANAGEMENT RISKS					
14	Time for project preparation	contractor	owner	construction manager	Poor planning that could lead to higher costs in later stages
15	Misunderstanding of project	contractor	contractor	construction manager	Additional changes in the project, project delay
16	Insufficient information about the project	owner	owner	construction manager	Additional changes in the project
17	Estimating or scheduling errors	contractor	contractor	construction manager	Changes in costs, project delay
18	Lack of cooperation between stakeholders	owner	owner	owner / CM	Additional changes in the project
19	Inexperienced staff	contractor	contractor	construction manager	Possibility of the occurrence of errors
20	Stakeholders request late changes	owner	owner	owner / CM	Additional changes in the project, increase in costs, project delay
21	Experience with similar project	contractor	contractor	construction manager	Experience leads to decrease of mistakes
22	Local communities pose objections	owner / contractor	owner	owner / CM	Problems with permissions
23	New information required for permits	contractor	owner	construction manager	Project delay
PROCUREMENT STAGE					
CONSTRUCTION RISKS					
24	Subcontractors	contractor	contractor	construction manager	Bad quality of performance, project delay, changes in costs
25	Material resources	contractor	contractor	construction manager	Project delay, changes in cost
26	Stakeholders request late changes	owner	owner	owner / CM	Additional changes in the project, increase in cost, project delay
CONSTRUCTION STAGE					
CONSTRUCTION RISKS					
27	Time for project preparation	contractor	contractor	construction manager	Poor planning that could lead to higher costs in later stages
28	Misunderstanding of project	contractor	contractor	construction manager	Additional changes in the project, project delay
29	Insufficient information about the project	owner	owner	construction manager	Additional changes in the project
30	Estimating or scheduling errors	contractor	contractor	construction manager	Changes in costs, project delay
31	Lack of cooperation between stakeholders	owner	owner	owner / CM	Additional changes in the project
32	Inexperienced staff	contractor	contractor	construction manager	Possibility of the occurrence of errors, project delay
33	Consultant or contractor delays	contractor	contractor	construction manager	Project delay, increase in costs
34	No control over staff priorities	contractor	contractor	construction manager	Bad quality of performance, project delay
35	Changes during construction	owner / contractor	owner / contractor	construction manager	Additional changes in the project, increase in cost, project delay
36	Building permit	contractor	owner	construction manager	Project delay or construction annulment
37	Material resources	contractor	contractor	construction manager	Project delay, changes in costs
38	Geological conditions	contractor	contractor	construction	Project delay, increase in

				manager	costs
39	Difficult technical solution	contractor	contractor	construction manager	Difficult solution brings more problems
40	Subcontractors	contractor	contractor	construction manager	Bad quality of performance, project delay, changes in costs
41	Experience with similar project	contractor	contractor	construction manager	Experience leads to decrease of mistakes
42	Losing critical staff at crucial point of the project	contractor	contractor	construction manager	Clueless staff
43	Insurance	contractor	contractor	construction manager	Insurance of the contractor
EXTERNAL RISKS					
44	Site access	contractor	owner	construction manager	Increase in cost
45	Historic site, endangered species or wetlands present	contractor	contractor	construction manager	Project delay, increase in cost
46	New information required for permits	contractor	contractor	construction manager	Project delay
47	Political situation	owner	owner	owner	Changes in the project, project delay
48	Storm	contractor	contractor	construction manager	Damage to the project, project delay, increase in cost
49	Labor shortage or strike	contractor	contractor	construction manager	Project delay
50	Terrorism	owner	owner	owner	Damage to the project, project delay, increase in cost
FINANCIAL RISKS					
51	Warranty	owner	owner	owner / CM	Protection of the owner
52	Liability of the bills	contractor	contractor	subcontractors	Fines for breaching the contractual terms
53	Financing of the project	owner	owner	owner	The project will not be finished without sufficient funds
54	Financial situation of the contractor	contractor	contractor	subcontractors	Project delay, insolvency of the contractor
ENVIRONMENTAL RISKS					
55	Environmental aspects	contractor	contractor	construction manager	Fines for breaching the laws and regulations
56	Contaminated soil	contractor	contractor	CM / subcontractors	Fines for contaminated soil, reparations
57	Contaminated water	contractor	contractor	CM / subcontractors	Fines for contaminated water, reparations
58	Environmental regulations change	contractor	contractor	construction manager	Possibility of project scope changes, project delay
POST-CONSTRUCTION STAGE					
CONSTRUCTION RISKS					
59	Poor work quality	contractor	contractor	CM / subcontractors	Defects reparation, project delay
60	Big amount of unremoved defects	contractor	contractor	CM / subcontractors	Defects reparation, project delay
61	Claims	contractor	contractor	CM / subcontractors	Defects reparation, project delay
FINANCIAL RISKS					
62	Warranty	owner	owner	owner / CM	Protection of the owner
63	Financing of the project	owner	owner	owner	The project will not be finished without sufficient funds
64	Sum of the retaining money	contractor	contractor	subcontractors	Protection of the owner against defects caused by contractor

OWNER OCCUPANCY STAGE			
MAINTENANCE RISKS			
65	Lack of skilled maintenance labor	owner	Increase in cost
66	Building fabric / component failure	owner	Repairs, additional costs
67	Poor quality maintenance regime	owner	Repairs, additional costs
68	Increased demands on M&E equipment	owner	Additional costs
69	Unexpected plant and equipment obsolescence	owner	Repairs, additional costs
ENERGY RISKS			
70	Increase in unit cost of energy	owner	Increase in cost
71	Increase in demand for energy supply	owner	Increase in cost
72	Non-competitive pricing/quotes	owner	Increase in cost
73	Failure in energy supply	owner	Impossibility of building operation, increase in cost
74	Failure in energy efficiency measures	owner	Increase in cost
EXTERNAL RISKS			
75	Dependency on key suppliers	owner	Dependency on the prices of the suppliers, increase in cost
76	Failure of supplier to meet agreed operational standard	owner	Searching for other suppliers, increase in cost
77	Theft of assets from within the building and other security failures	owner	Damages, additional costs
78	High staff turnover, low staff base	owner	Clueless staff, costs for staff training
79	Building overoccupancy	owner	Obsolescence, additional costs for repairs
80	Political situation	owner	Changes in the requirements, additional costs
81	Terrorism	owner	Damage to the building, costs for repairs
FINANCIAL RISKS			
82	Increases in interest rates	owner	Increase in cost
83	Lack of future investment in capital	owner	Needs of funds, loans; additional costs
84	Increased financial liabilities	owner	Needs of funds, loans; additional costs
85	Disposal risk	owner	Additional costs

5.2.3. QUALITATIVE RISK ANALYSIS

The third step is to perform qualitative risk analysis to describe the extent of potential consequences and the likelihood that these consequences occur.

In this assessment the risks are grouped by phases of the whole life cycle and further by impacted area. Further steps are to determine the risk probability and risk impact and to use Probability and impact matrix to prioritize the risks. (Described in paragraph 4.3.2.)

Risk Probability

- **Remote (Very low)**
  - Risk is extremely unlikely to occur. 0-20%
- **Unlikely (Low)**
  - Risk is unlikely to occur. 21-40%
- **Occasional (Medium)**
  - There is a possible chance that the risk will occur. 41-60%
- **Likely (High)**
  - It is highly likely that the risk will occur. 61-80%
- **Definitely (Very high)**
  - It is almost a certainty that the risk will occur. 81-100%

Risk impact

- **Insignificant (Very low)**
  - Risks which do not pose any significant threat and which can be left unmediated without any fear.
- **Marginal (Low)**
  - Any risks which will have just a mild impact on the project, still these must be addressed in time.
- **Moderate**
  - Risks which will cause some problems, but nothing too significant.
- **Critical (High)**
  - Risks which can significantly jeopardize some aspects of the project, but which will not completely ruin the project.
- **Catastrophic (Very high)**
  - A risk that can prove detrimental for the whole project.

Assessment levels

- **Green (Low Risk)**

The risks in the green are nearly harmless and in most cases these risks can be safely ignored. Most risks in this category don't require any mediation at all.

- **Yellow (Moderate Risk)**

These are risks which can be left out during the formulation of risk management strategies, as these are low priority risks and can be handled as and when they arise. However, that does not mean these risks can be ignored altogether.

- **Orange (High Risk)**

These are the risks that again must be optimally addressed; however they do not enjoy top priority like the risks in red cells. These are also significant risks and it's advisable to have them included in the risk management strategies.

- **Red (Extreme Risk)**

All risks that fall in the red cells are of utmost importance. Prevention and mitigation strategies for all these risks must be framed much in advance so as to prevent their occurrence or to fight them back as soon as they surface up.

In the table below (Updated risk register) there are described identified risks with their likelihood and impact.

Abbreviations used in the following table:

LH = likelihood, IM = impact, ORA = overall risk assessment, D&B = design & build, DBB = design-bid-build, CM = professional construction management, VL = very low, L = low, M = moderate / medium, H = high, VH = very high, LR = low risk, MR = moderate risk, HR = high risk, ER = extreme risk

Table 3: UPDATED RISK REGISTER – QUALITATIVE RISK ANALYSIS

ID	RISK	D&B			DBB			CM		
		LH	IM	ORA	LH	IM	ORA	LH	IM	ORA
DESIGN AND BIDDING STAGE										
ENVIRONMENTAL RISKS										
1	Incomplete environmental analysis	M	VL	LR	M	L	MR	M	VL	LR
2	Environmental regulations change	VL	M	LR	VL	M	LR	VL	M	LR
DESIGN RISKS										
3	Misunderstanding of task	M	H	ER	M	M	HR	M	M	HR
4	Insufficient information about the project	M	VH	ER	M	H	ER	M	H	ER
5	Owner involvement in design	VL	L	LR	M	L	MR	M	L	MR
6	Problems with design	L	H	HR	VH	VH	ER	H	H	ER
7	Not efficient solution of design	L	H	HR	H	H	ER	L	H	HR
8	Incomplete design	M	H	ER	M	VH	ER	M	VH	ER
9	New design standard	VL	VL	LR	VL	VL	LR	VL	VL	LR
CONTRACT RISKS										
10	Type of contract	L	M	MR	L	M	MR	L	M	MR
11	Contract conditions	M	H	ER	M	H	ER	M	H	ER
12	Lack of cooperation between stakeholders	M	L	MR	L	L	LR	L	L	LR
13	Variations in price and foreign exchange	M	L	MR	M	L	MR	M	L	MR
PRE-CONSTRUCTION STAGE										
PROJECT MANAGEMENT RISKS										
14	Time for project preparation	VL	M	LR	VL	H	MR	VL	H	MR
15	Misunderstanding of project	M	H	ER	M	M	HR	M	M	HR
16	Insufficient information about the project	M	VH	ER	M	H	ER	M	H	ER

17	Estimating or scheduling errors	M	H	ER	M	H	ER	M	H	ER
18	Lack of cooperation between stakeholders	M	L	MR	L	L	LR	L	L	LR
19	Inexperienced staff	VL	M	LR	M	M	HR	L	M	MR
20	Stakeholders request late changes	M	H	ER	M	M	HR	M	L	MR
21	Experience with similar project	VL	M	LR	VL	M	LR	L	M	MR
22	Local communities pose objections	VL	M	LR	VL	M	LR	VL	M	LR
23	New information required for permits	L	H	HR	L	H	HR	L	H	HR
PROCUREMENT STAGE										
CONSTRUCTION RISKS										
24	Subcontractors	M	H	ER	M	H	ER	M	H	ER
25	Material resources	VL	VL	LR	VL	VL	LR	VL	VL	LR
26	Stakeholders request late changes	M	VH	ER	M	VH	ER	M	H	ER
CONSTRUCTION STAGE										
CONSTRUCTION RISKS										
27	Time for project preparation	VL	M	LR	VL	H	MR	VL	H	MR
28	Misunderstanding of project	M	H	ER	M	M	HR	M	M	HR
29	Insufficient information about the project	M	VH	ER	M	H	ER	M	H	ER
30	Estimating or scheduling errors	M	VH	ER	M	VH	ER	M	H	ER
31	Lack of cooperation between stakeholders	M	L	MR	L	L	LR	L	L	LR
32	Inexperienced staff	VL	M	LR	VL	M	LR	L	M	MR
33	Consultant or contractor delays	VL	L	LR	VL	M	LR	VL	L	LR
34	No control over staff priorities	L	M	MR	L	M	MR	L	L	LR
35	Changes during construction	M	H	ER	M	H	ER	M	M	HR
36	Building permit	VL	M	LR	VL	M	LR	VL	M	LR
37	Material resources	VL	VL	LR	VL	VL	LR	VL	VL	LR
38	Geological conditions	L	L	LR	L	L	LR	L	L	LR
39	Difficult technical solution	L	M	LR	L	M	MR	L	M	MR
40	Subcontractors	M	H	ER	M	H	ER	M	H	ER
41	Experience with similar project	VL	M	LR	VL	M	LR	L	M	MR
42	Losing critical staff at crucial point of the project	M	H	ER	M	H	ER	M	VH	ER
43	Insurance	M	M	HR	M	M	HR	L	M	MR
EXTERNAL RISKS										
44	Site access	VL	VL	LR	VL	VL	LR	VL	VL	LR
45	Historic site, endangered species or wetlands present	L	L	LR	L	L	LR	L	L	LR
46	New information required for permits	L	H	HR	L	H	HR	L	H	HR
47	Political situation	M	L	MR	M	L	MR	M	L	MR
48	Storm	VL	VH	HR	VL	VH	HR	VL	VH	HR
49	Labor shortage or strike	VL	H	MR	VL	H	MR	VL	H	MR
50	Terrorism	VL	M	LR	VL	M	LR	VL	M	LR
FINANCIAL RISKS										
51	Warranty	M	L	MR	M	L	MR	M	VL	LR
52	Liability of the bills	H	H	ER	H	H	ER	H	M	HR

53	Financing of the project	VL	H	MR	VL	H	MR	VL	H	MR
54	Financial situation of the contractor	L	VH	ER	L	VH	ER	L	H	HR
	ENVIRONMENTAL RISKS									
55	Environmental aspects	VL	L	LR	VL	L	LR	VL	L	LR
56	Contaminated soil	VL	L	LR	VL	L	LR	VL	L	LR
57	Contaminated water	VL	L	LR	VL	L	LR	VL	L	LR
58	Environmental regulations change	VL	M	LR	VL	M	LR	VL	M	LR
POST-CONSTRUCTION STAGE										
	CONSTRUCTION RISKS									
59	Poor work quality	L	M	MR	M	M	HR	L	L	LR
60	Big amount of unremoved defects	L	M	MR	L	M	MR	VL	M	LR
61	Claims	M	L	MR	M	L	MR	L	L	LR
	FINANCIAL RISKS									
62	Warranty	M	L	MR	M	L	MR	M	VL	LR
63	Financing of the project	VL	H	MR	VL	H	MR	VL	H	MR
64	Sum of the retaining money	L	H	HR	L	H	HR	L	M	MR

OWNER OCCUPANCY STAGE				
ID	**RISK**	**LIKELIHOOD**	**IMPACT**	**OVERALL RISK ASSESSMENT**
	MAINTENANCE RISKS			
65	Lack of skilled maintenance labor	L	H	HR
66	Building fabric / component failure	M	M	HR
67	Poor quality maintenance regime	L	M	MR
68	Increased demands on M&E equipment	VL	L	LR
69	Unexpected plant and equipment obsolescence	VL	M	LR
	ENERGY RISKS			
70	Increase in unit cost of energy	VH	M	ER
71	Increase in demand for energy supply	M	H	ER
72	Non-competitive pricing/quotes	VH	L	HR
73	Failure in energy supply	VL	M	LR
74	Failure in energy efficiency measures	L	L	LR
	EXTERNAL RISKS			
75	Dependency on key suppliers	L	L	LR
76	Failure of supplier to meet agreed operational standard	M	L	MR
77	Theft of assets from within the building and other security failures	H	L	HR
78	High staff turnover, low staff base	M	M	HR
79	Building overoccupancy	L	L	LR
80	Political situation	M	L	MR
82	Terrorism	VL	M	LR
	FINANCIAL RISKS			
83	Increases in interest rates	M	L	MR

84	Lack of future investment in capital	VL	M	LR
85	Increased financial liabilities	M	M	HR
86	Disposal risk	L	M	MR

5.2.4. QUANTITATIVE RISK ANALYSIS

The fourth step is to further analyse the high priority risks. The goal of this assessment is to estimate the frequency and the severity of losses endangering the project and prioritize the risks by their cost. (Described in paragraph 4.4.2.)

At that moment risks are prioritized and according to the assessment levels risks are divided into four groups: green – low risks; yellow – moderate risks; orange – high risks; red – extreme risks.

The further assessment is focused on the high risks and extreme risks which require immediate attention.

The cost of this construction project was 282 million CZK. The impact in percentage of total cost is estimated based on other studies of risk management[65,66].

In the table below (Updated risk register) there are described identified risks with their likelihood and expected monetary value.

Abbreviations used in the following table:

IM = impact, TC = total cost, D&B = design & build, DBB = design-bid-build, CM = professional construction management, LH = likelihood, EMV = expected monetary value, thsd. = thousands

Table 4: UPDATED RISK REGISTER – QUANTITATIVE ANALYSIS

ID	RISK	IM (% of TC)	COST OF IM (in thsd. CZK)	D&B		DBB		CM	
				LH	EMV (in thsd. CZK)	LH	EMV (in thsd. CZK)	LH	EMV (in thsd. CZK)
DESIGN AND BIDDING STAGE									
DESIGN RISKS									
3	Misunderstanding of task	0.5	1,410	0.5	705	0.5	705	0.5	705
4	Insufficient information about the project	1	2,820	0.5	1,410	0.5	1,410	0.5	1,410
6	Problems with	0.1	282	0.3	85	0.9	254	0.7	197

[65] DRNEK, Ondřej. *Risk Management in a Real Construction Project*.

[66] ŠEDIVÁ, Simona. *Risk Management in a Historical Reconstructions*.

	design								
7	Not efficient solution of design	5	14,100	0.3	4,230	0.7	9,870	0.3	4,230
8	Incomplete design	1	2,820	0.5	1,410	0.5	1,410	0.5	1,410
CONTRACT RISKS									
11	Contract conditions	0.3	846	0.5	423	0.5	423	0.5	423
PRE-CONSTRUCTION STAGE									
PROJECT MANAGEMENT RISKS									
15	Misunderstanding of project	1	2,820	0.5	1,410	0.5	1,410	0.5	1,410
16	Insufficient information about the project	1.5	4,230	0.5	2,115	0.5	2,115	0.5	2,115
17	Estimating or scheduling errors	1	2,820	0.5	1,410	0.5	1,410	0.5	1,410
19	Inexperienced staff	0.5	1,410	0.1	141	0.5	705	0.3	423
20	Stakeholders request late changes	2	5,640	0.5	2,820	0.5	2,820	0.5	2,820
23	New information required for permits	0.2	564	0.3	169	0.3	169	0.3	169
PROCUREMENT STAGE									
CONSTRUCTION RISKS									
24	Subcontractors	0.3	846	0.5	423	0.5	423	0.5	423
26	Stakeholders request late changes	3	8,460	0.5	4,230	0.5	4,230	0.5	4,230
CONSTRUCTION STAGE									
CONSTRUCTION RISKS									
28	Misunderstanding of project	3	11,280	0.5	4,230	0.5	4,230	0.5	4,230
29	Insufficient information about the project	2.5	7,050	0.5	3,525	0.5	3,525	0.5	3,525
30	Estimating or scheduling errors	1.5	4,230	0.5	2,115	0.5	2,115	0.5	2,115
35	Changes during construction	2	5,640	0.5	2,820	0.5	2,820	0.5	2,820
40	Subcontractors	0.5	1,410	0.5	705	0.5	705	0.5	705
42	Losing critical staff at crucial point of the project	0.2	564	0.5	282	0.5	282	0.5	282
43	Insurance	0.05	141	0.5	71	0.5	71	0.3	42
EXTERNAL RISKS									
46	New information required for permits	0.2	564	0.3	169	0.3	169	0.3	169
48	Storm	6	16,920	0.1	1,692	0.1	1,692	0.1	1,692
FINANCIAL RISKS									
52	Liability of the bills	0.1	282	0.7	197	0.7	197	0.7	197
54	Financial situation of the contractor	2	5,640	0.3	1,692	0.3	1,692	0.3	1,692
POST-CONSTRUCTION STAGE									
CONSTRUCTION RISKS									
59	Poor work quality	30	84,600	0.3	25,380	0.5	42,300	0.3	25,380
FINANCIAL RISKS									
64	Sum of the retaining money	2	5,640	0.3	1,692	0.3	1,692	0.3	1,692
OWNER OCCUPANCY STAGE									
ID	**RISK**	**IM (% of TC)**	**COST OF IM (in thsd. CZK)**	**LH**			**EMV (in thsd. CZK)**		
MAINTENANCE RISKS									
65	Lack of skilled maintenance labor	5	14,100	0.3			4,230		

66	Building fabric / component failure	15	42,300	0.5	21,150
ENERGY RISKS					
70	Increase in unit cost of energy	1	2,820	0.9	2,538
71	Increase in demand for energy supply	2	5,640	0.5	2,820
72	Non-competitive pricing/quotes	0.5	1,410	0.9	1,269
EXTERNAL RISKS					
77	Theft of assets from within the building and other security failures	5	14,100	0.7	9,870
78	High staff turnover, low staff base	2	5,640	0.5	2,820
FINANCIAL RISKS					
84	Increased financial liabilities	2	5,640	0.5	2,820

5.2.5. RISK RESPONSES

The fifth step is to develop the options and the actions how to deal with each risk.

The further assessment is focused on the high risks and extreme risks which require immediate attention; their impact is estimated by quantitative analysis.

In the table below (Updated risk register) there are described identified risks with their response strategies.

Abbreviations used in the following table:

D&B = design & build, DBB = design-bid-build, CM = professional construction management / manager, C = contractor, S = subcontractors, O = owner, RO = risk owner, EMV = expected monetary value

Table 5: UPDATED RISK REGISTER – RISK RESPONSES

ID	RISK	D&B		DBB		CM		RISK RESPONSE
		RO	EMV (in thsd. CZK)	RO	EMV (in thsd. CZK)	RO	EMV (in thsd. CZK)	
DESIGN AND BIDDING STAGE								
DESIGN RISKS								
3	Misunderstanding of task	C	705	O	705	CM	705	MITIGATE
4	Insufficient information about the project	O	1,410	O	1,410	O	1,410	MITIGATE
6	Problems with design	C	85	O	254	CM	197	MITIGATE / TRANSFER
7	Not efficient solution of design	C	4,230	O	9,870	CM	4,230	AVOID
8	Incomplete design	C	1,410	O	1,410	CM	1,410	MITIGATE /

								TRANSFER
CONTRACT RISKS								
11	Contract conditions	O/C	423	O/C	423	O / CM	423	MITIGATE
PRE-CONSTRUCTION STAGE								
PROJECT MANAGEMENT RISKS								
15	Misunderstanding of project	C	1,410	C	1,410	CM	1,410	MITIGATE
16	Insufficient information about the project	O	2,115	O	2,115	CM	2,115	MITIGATE
17	Estimating or scheduling errors	C	1,410	C	1,410	CM	1,410	TRANSFER
19	Inexperienced staff	C	141	C	705	CM	423	TRANSFER
20	Stakeholders request late changes	O	2,820	O	2,820	O / CM	2,820	MITIGATE
23	New information required for permits	C	169	O	169	CM	169	MITIGATE
PROCUREMENT STAGE								
CONSTRUCTION RISKS								
24	Subcontractors	C	423	C	423	CM	423	TRANSFER
26	Stakeholders request late changes	O	4,230	O	4,230	O / CM	4,230	MITIGATE
CONSTRUCTION STAGE								
CONSTRUCTION RISKS								
28	Misunderstanding of project	C	4,230	C	4,230	CM	4,230	MITIGATE
29	Insufficient information about the project	O	3,525	O	3,525	CM	3,525	MITIGATE
30	Estimating or scheduling errors	C	2,115	C	2,115	CM	2,115	TRANSFER
35	Changes during construction	O/C	2,820	O/C	2,820	CM	2,820	AVOID / MITIGATE / TRANSFER
40	Subcontractors	C	705	C	705	CM	705	TRANSFER
42	Losing critical staff at crucial point of the project	C	282	C	282	CM	282	MITIGATE
43	Insurance	C	71	C	71	CM	42	MITIGATE
EXTERNAL RISKS								
46	New information required for permits	C	169	C	169	CM	169	MITIGATE
48	Storm	C	1,692	C	1,692	CM	1,692	AVOID / TRANSFER
FINANCIAL RISKS								
52	Liability of the bills	C	197	C	197	S	197	AVOID
54	Financial situation of the contractor	C	1,692	C	1,692	S	1,692	MITIGATE
POST-CONSTRUCTION STAGE								
CONSTRUCTION RISKS								
59	Poor work quality	C	25,380	C	42,300	CM / S	25,380	MITIGATE / TRANSFER
FINANCIAL RISKS								
64	Sum of the retaining money	C	1,692	C	1,692	S	1,692	MITIGATE
OWNER OCCUPANCY STAGE								
ID	**RISK**	**RO**			**EMV**			**RISK RESPONSE**
MAINTENANCE RISKS								
65	Lack of skilled maintenance labor	owner			4,230			MITIGATE / TRANSFER
66	Building fabric / component failure	owner			21,150			MITIGATE / TRANSFER
ENERGY RISKS								
70	Increase in unit cost of energy	owner			2,538			ACCEPT / AVOID
71	Increase in demand for energy supply	owner			2,820			MITIGATE
72	Non-competitive	owner			1,269			ACCEPT / AVOID

	pricing/quotes			
EXTERNAL RISKS				
77	Theft of assets from within the building and other security failures	owner	9,870	AVOID / TRANSFER
78	High staff turnover, low staff base	owner	2,820	MITIGATE
FINANCIAL RISKS				
84	Increased financial liabilities	owner	2,820	MITIGATE

Risk treatment

The ability of the parties to influence project outcomes, including reduction of cost, creation of additional value, improvement of performance and flexibility to incorporate changes is much higher in the earlier conceptual and design stages of the project. Therefore, it is advisable to identify, assess and solve risk before the project will start. But not just at the beginning, the risks develop throughout the whole life cycle of construction; for this reason it is necessary to repeat the risk assessments.

The decision-making how to deal with risk should be chosen for each risk individually.

The risk treatment for risks listed in table 5 is described in detail below.

DESIGN AND BIDDING STAGE

ID 3 – Misunderstanding of task

The chosen risk treatment is to mitigate the risk. The big problem could occur already at the beginning of the project with the incomprehension of the project task; therefore it is necessary that all parties are properly informed. That could be solved by meetings of stakeholders.

ID 4 – Insufficient information about the project

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method the owner should accurately and clearly specify his project goals and requirements; they should be generally described in the contract.

ID 6 – Problem with design

The chosen risk treatment is to mitigate or transfer the risk. The project documentation should be done by some reputable design company. Or the owner could transfer the risk by selecting the project delivery method. When the owner decides to choose the design and build, the risk will be transferred to the contractor and the contractor will handle them at his own expenses.

ID 7 – Not efficient solution of design

The chosen risk treatment is to avoid the risk. Inefficient solution brings problems not only in construction phase but also in others, especially in the operational stage where the consequences could be serious. It is necessary to eliminate it.

ID 8 – Incomplete design

The chosen risk treatment is to mitigate or transfer the risk. The construction cannot start without complete project documentation, it causes the delay. The project documentation should be done by some reputable design company and the owner should ensure that the design will be done on time. Or he could transfer the risk by selecting the project delivery method. When the owner decides to choose the design and build, the risk will be transferred to the contractor and the contractor will handle them at his own expenses.

ID 11 – Contract conditions

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method there is a need for parties to agree on the contract conditions.

PRE-CONSTRUCTION STAGE

ID 15 – Misunderstanding of project

The chosen risk treatment is to mitigate the risk. It is necessary that all parties are properly informed about their project work. That could be solved by meetings of stakeholders.

ID 16 – Insufficient information about the project

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method the owner should accurately and clearly specify his project goals and requirements; they are generally described in the contract.

ID 17 – Estimating or scheduling errors

The chosen risk treatment is to transfer the risk. The estimating and scheduling errors could have huge impact on project delay and particularly on increase in cost. That could be resolved by transferring the risk from the owner to other party; the transference could be done by selecting the right project delivery method and type of contract.

ID 19 – Inexperienced staff

The chosen risk treatment is to transfer the risk. When talking about the hotel construction the owner usually do not have much experience with construction or experienced staff; therefore it is advisable to transfer these risks to other party by selecting the right project delivery method.

ID 20 – Stakeholders request late changes

The chosen risk treatment is to mitigate the risk. Stakeholders' late requests for changes are very common; it is appropriate to in advance organize more meetings with stakeholders to reduce the late changes.

ID 23 – New information required for permits

The chosen risk treatment is to mitigate the risk. It is advisable to detect the necessary information in advance and monitoring the requirements.

PROCUREMENT STAGE

ID 24 – Subcontractors

The chosen risk treatment is to transfer the risk. The coordination of subcontractors could be demanding, therefore it is appropriate to transfer the risk to person or company with more experience by the selecting the project delivery method.

ID 26 – Stakeholders request late changes

The chosen risk treatment is to mitigate the risk. Stakeholders' late requests for changes are very common; it is appropriate to in advance organize more meetings with stakeholders to reduce the late changes.

CONSTRUCTION STAGE

ID 28 – Misunderstanding of project

The chosen risk treatment is to mitigate the risk. It is necessary that all parties are properly informed about their project work. That could be solved by meetings of stakeholders.

ID 29 – Insufficient information about the project

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method the owner should accurately and clearly specify his project goals and requirements; they are generally described in the contract.

ID 30 – Estimate or scheduling errors

The chosen risk treatment is to transfer the risk. The estimating and scheduling errors could have huge impact on project delay and particularly on increase in cost. That could be resolved by transferring the risk from the owner to other party; the transference could be done by selecting the right project delivery method and type of contract.

ID 35 – Changes during construction

The chosen risk treatment is to avoid or mitigate or transfer the risk. It is appropriate to in advance organize more meetings to reduce the late changes. By some type of contract some risks of changes could be transfer to the contractor.

ID 40 - Subcontractors

The chosen risk treatment is to transfer the risk. The coordination of subcontractors could be demanding, therefore it is appropriate to transfer the risk to person or company with more experience by the selecting the project delivery method.

ID 42 – Losing critical staff at crucial point of the project

The chosen risk treatment is to mitigate the risk. Losing critical staff could have huge impact but this can be prevented by well training of the whole project team and that the information about project is recorded and shared.

ID 43 - Insurance

The chosen risk treatment is to mitigate the risk. The contractor should have insurance of the construction against unusual events such as fire, flood etc. The insurance company takes the responsibility.

ID 46 – New information required for permits

The chosen risk treatment is to mitigate the risk. It is advisable to detect the necessary information in advance and monitoring the requirements.

ID 48 - Storm

The chosen risk treatment is to avoid or transfer the risk. It is necessary to ensure the providing of regular updates of weather conditions that there could be possibility to change the plan. The risk could be also transfer to the third party like insurance company.

ID 52 – Liability of the bills

The chosen risk treatment is to avoid the risk. In the contract there are usually described fines for overdue payments. The owner should insure that the payments will not be after due date.

ID 54 – Financial situation of the contractor

The chosen risk treatment is to mitigate the risk. Already in the bidding phase the owner should find out the credibility of the contractor.

POST-CONSTRUCTION STAGE

ID 59 – Poor work quality

The chosen risk treatment is to mitigate or transfer the risk. The owner should select experience contractor and ensure that the fines for the defects are specified in the contract. With the selecting of the project delivery method the owner transfers the risk of poor quality to the contractor.

ID 64 – Sum of the retaining money

The chosen risk treatment is to mitigate the risk. The retaining money serves as protection of the owner and “insures” that the contractor will finish all the works, remove all the defects and clear backlog.

OWNER OCCUPANCY STAGE

ID 65 – Lack of skilled maintenance labor

The chosen risk treatment is to mitigate or transfer the risk. The owner should ensure staff training and more intensive inspection of works. Also he could transfer the risk to the company providing the facility management.

ID 66 – Building fabric / component failure

The chosen risk treatment is to mitigate or transfer the risk. The owner should ensure effective maintenance regimes and regular condition assessments. The risk could be transfer to the other party like insurance company.

ID 70 – Increase in unit cost of energy

The chosen risk treatment is to accept or avoid the risk. The owner should continually monitor the market prices. But within the energy cost there are not many options.

ID 71 – Increase in demand for energy supply

The chosen risk treatment is to mitigate the risk. The owner should ensure that the efficiency measures are working correctly.

ID 72 – Non-competitive pricing / quotes

The chosen risk treatment is to accept or avoid the risk. The owner should continually monitor the market prices. But within the energy cost there are not many options.

ID 77 – Theft of assets from within the building and other security failures

The chosen risk treatment is to avoid or transfer the risk. The owner should ensure regular asset auditing and strengthen security system. The risk could be transfer to the other party like insurance company.

ID 78 – High staff turnover, low staff base

The chosen risk treatment is to mitigate the risk. The owner should enhance relationships with management and workforce; ensure better training and commitment to investment in the workforce.

ID 84 – Increased financial liabilities

The chosen risk treatment is to mitigate the risk. The owner should have effective financial management protocol and minimise the need for loans.

5.2.6. RISK CONTROL

Sixth step is monitoring of the risks. Risk control is based on continuous risk monitoring and assessments throughout the whole life cycle of construction. It is necessary to identify new risks which could have a huge impact on the project or the current but with different impact. It is also advisable to perform audits to know what effectiveness the risk approach has.

5.3. PROJECT NO. 2 – HOTEL RECONSTRUCTION

The second construction project on which the risk management will be performed is the conversion of the House of Trades union services into hotel building. This building is located in Ostrava. It is historical building that was built in 1928 as an office building together with rental apartments. Since 1992 this historic building has been within the urban conservation area and in 2008 it became the Cultural monument.

In 2008 the building was bought by private owner for the purpose of rebuilding on hotel. The reconstruction took place in 2009-2010. The hotel was opened in March 2011. The cost of this reconstruction was 250 million CZK.

5.3.1. IDENTIFICATION OF STAKEHOLDERS

The first step is to identify people, groups, or organizations that could affect the project.

In the table below (Stakeholder register) there are described some stakeholders and their roles in the project.

Table 6: STAKEHOLDER REGISTER

STAKEHOLDER	DESCRIPTION	ROLE IN PROJECT
OWNER	CZECH COMPANY	To manage the financing of the project
	PARENT COMPANY	To specify the technical requirements of the project
PROJECT MANAGEMENT	KN PROJECT - Ing. Petr Knápek	To provide the control of the project from the owner perspective
FINANCING BANK	UnitCredit Bank Czech Republic, a.s.	To provide the financial support
DESIGN TEAM	JART-JANDA spol. s r.o.	To provide the project documentation and technical supervision
CONTRACTOR COMPANY	P r ů m s t a v, a.s.	To provide the construction works
CONTRACTOR PROJECT TEAM	Project team P r ů m s t a v, a.s.	To manage the construction works
SUBCOTRACTORS	Subcontractors of the Construction company	To provide the partial construction works
SUPPLIERS	Suppliers of the Construction company	To provide the material
OPERATOR OF TECHNICAL NETWORKS - WATER	Ostravské vodárny a kanalizace a.s.	To provide the water network
OPERATOR OF TECHNICAL NETWORKS - SEWER SYSTEM	Ostravské vodárny a kanalizace a.s.	To provide the sewer system network
OPERATOR OF TECHNICAL NETWORKS - ELECTRICITY	ČEZ prodej, s.r.o.	To provide the electricity network
OPERATOR OF TECHNICAL NETWORKS - HEATING	Dalkia Česká republika, a.s.	To provide the heat supply
OPERATOR OF TECHNICAL NETWORKS - ELECTRONIC COMMUNICATIONS	Telefónica O2 Czech Republic, a.s.	To provide the electronic communications network
CONSTRUCTION AUTHORITY	Czech Construction Authority in Ostrava	To control the regulation compliance

ANTIQUITIES AUTHORITY	Czech Antiquities Authority in Ostrava	To control the regulation compliance
ENVIRONMENT AUTHORITY	Czech Environment Authority in Ostrava	To control the regulation compliance
HYGIENE AUTHORITY	Czech Hygiene Authority in Ostrava	To control the regulation compliance
FIRE PROTECTION AUTHORITY	Czech Fire Protection Authority in Ostrava	To control the regulation compliance
INFRASTRUCTURE AUTHORITY	Czech Infrastructure Authority in Ostrava	To control the regulation compliance
SAFETY AUTHORITY	Czech Safety Authority	To control the regulation compliance
OWNERS OF NEIGHBOURING LANDS	Owners of the neighbouring properties	To agree or disagree with the project

5.3.2. IDENTIFICATION OF RISKS

The second step is to identify risks and their impact on the project.

In the following table (Risk register) there are described some risks which can occur during the whole life cycle of the project. For better clarity the risks are categorized into groups according to the phase of the project life cycle.

Abbreviations used in the following table:

D&B = design & build, DBB = design-bid-build, CM = professional construction management / manager

Table 7: RISK REGISTER – RISK IDENTIFICATION

ID	RISK	RISK OWNER			IMPACT
		D&B	DBB	CM	
DESIGN AND BIDDING STAGE					
ENVIRONMENTAL RISKS					
1	Incomplete environmental analysis	contractor	owner	construction manager	Possibility of not issuing of needed permission
2	Environmental regulations change	contractor	owner	construction manager	Possibility of project scope changes, project delay
DESIGN RISKS					
3	Misunderstanding of task	contractor	owner	construction manager	Additional changes in the project
4	Insufficient information about the project	owner	owner	owner	Additional changes in the project
5	Owner involvement in design	owner	owner	owner	Additional changes in the project
6	Problems with design	contractor	owner	construction manager	Project delay
7	Not efficient solution of design	contractor	owner	construction manager	Additional changes in the project, higher costs in later stages
8	Incomplete design	contractor	owner	construction manager	Delay of the start of construction
9	New design standard	contractor	owner	construction manager	Changes in the project documentation, project delay
CONTRACT RISKS					

10	Type of contract	owner	owner	owner	Different responsibility of the risks
11	Contract conditions	owner / contractor	owner / contractor	owner / CM	Limited contract fines, conditions
12	Lack of cooperation between stakeholders	owner	owner	owner / CM	Additional changes in the project
13	Variations in price and foreign exchange	owner / contractor	owner / contractor	owner	Changes in costs
PRE-CONSTRUCTION STAGE					
PROJECT MANAGEMENT RISKS					
14	Time for project preparation	contractor	owner	construction manager	Poor planning that could lead to higher costs in later stages
15	Misunderstanding of project	contractor	contractor	construction manager	Additional changes in the project, project delay
16	Insufficient information about the project	owner	owner	construction manager	Additional changes in the project
17	Estimating or scheduling errors	contractor	contractor	construction manager	Changes in costs, project delay
18	Lack of cooperation between stakeholders	owner	owner	owner / CM	Additional changes in the project
19	Inexperienced staff	contractor	contractor	construction manager	Possibility of the occurrence of errors
20	Stakeholders request late changes	owner	owner	owner / CM	Additional changes in the project, increase in costs, project delay
21	Experience with similar project	contractor	contractor	construction manager	Experience leads to decrease of mistakes
22	Local communities pose objections	owner / contractor	owner	owner / CM	Problems with permissions
23	New information required for permits	contractor	owner	construction manager	Project delay
PROCUREMENT STAGE					
CONSTRUCTION RISKS					
24	Subcontractors	contractor	contractor	construction manager	Bad quality of performance, project delay, changes in costs
25	Material resources	contractor	contractor	construction manager	Project delay, changes in cost
26	Stakeholders request late changes	owner	owner	owner / CM	Additional changes in the project, increase in cost, project delay
CONSTRUCTION STAGE					
CONSTRUCTION RISKS					
27	Time for project preparation	contractor	contractor	construction manager	Poor planning that could lead to higher costs in later stages
28	Misunderstanding of project	contractor	contractor	construction manager	Additional changes in the project, project delay
29	Insufficient information about the project	owner	owner	construction manager	Additional changes in the project
30	Estimating or scheduling errors	contractor	contractor	construction manager	Changes in costs, project delay
31	Lack of cooperation between stakeholders	owner	owner	owner / CM	Additional changes in the project
32	Inexperienced staff	contractor	contractor	construction manager	Possibility of the occurrence of errors, project delay
33	Consultant or contractor delays	contractor	contractor	construction manager	Project delay, increase in costs
34	No control over staff priorities	contractor	contractor	construction manager	Bad quality of performance, project delay
35	Changes during construction	owner / contractor	owner / contractor	construction manager	Additional changes in the project, increase in

					cost, project delay
36	Building permit	contractor	owner	construction manager	Project delay or construction annulment
37	Material resources	contractor	contractor	construction manager	Project delay, changes in costs
38	Geological conditions	contractor	contractor	construction manager	Project delay, increase in costs
39	Difficult technical solution	contractor	contractor	construction manager	Difficult solution brings more problems
40	Subcontractors	contractor	contractor	construction manager	Bad quality of performance, project delay, changes in costs
41	Experience with similar project	contractor	contractor	construction manager	Experience leads to decrease of mistakes
42	Losing critical staff at crucial point of the project	contractor	contractor	construction manager	Clueless staff
43	Insurance	contractor	contractor	construction manager	Insurance of the contractor
EXTERNAL RISKS					
44	Site access	contractor	owner	construction manager	Increase in cost
45	Historic site, endangered species or wetlands present	contractor	contractor	construction manager	Project delay, increase in cost
46	New information required for permits	contractor	contractor	construction manager	Project delay
47	Political situation	owner	owner	owner	Changes in the project, project delay
48	Storm	contractor	contractor	construction manager	Damage to the project, project delay, increase in cost
49	Labor shortage or strike	contractor	contractor	construction manager	Project delay
50	Terrorism	owner	owner	owner	Damage to the project, project delay, increase in cost
FINANCIAL RISKS					
51	Warranty	owner	owner	owner / CM	Protection of the owner
52	Liability of the bills	contractor	contractor	subcontractors	Fines for breaching the contractual terms
53	Financing of the project	owner	owner	owner	The project will not be finished without sufficient funds
54	Financial situation of the contractor	contractor	contractor	subcontractors	Project delay, insolvency of the contractor
ENVIRONMENTAL RISKS					
55	Environmental aspects	contractor	contractor	construction manager	Fines for breaching the laws and regulations
56	Contaminated soil	contractor	contractor	CM / subcontractors	Fines for contaminated soil, reparations
57	Contaminated water	contractor	contractor	CM / subcontractors	Fines for contaminated water, reparations
58	Environmental regulations change	contractor	contractor	construction manager	Possibility of project scope changes, project delay
POST-CONSTRUCTION STAGE					
CONSTRUCTION RISKS					
59	Poor work quality	contractor	contractor	CM / subcontractors	Defects reparation, project delay
60	Big amount of unremoved defects	contractor	contractor	CM / subcontractors	Defects reparation, project delay
61	Claims	contractor	contractor	CM / subcontractors	Defects reparation, project delay
FINANCIAL RISKS					
62	Warranty	owner	owner	owner / CM	Protection of the owner

63	Financing of the project	owner	owner	owner	The project will not be finished without sufficient funds
64	Sum of the retaining money	contractor	contractor	subcontractors	Protection of the owner against defects caused by contractor
OWNER OCCUPANCY STAGE					
MAINTENANCE RISKS					
65	Lack of skilled maintenance labor	owner			Increase in cost
66	Building fabric / component failure	owner			Repairs, additional costs
67	Poor quality maintenance regime	owner			Repairs, additional costs
68	Increased demands on M&E equipment	owner			Additional costs
69	Unexpected plant and equipment obsolescence	owner			Repairs, additional costs
ENERGY RISKS					
70	Increase in unit cost of energy	owner			Increase in cost
71	Increase in demand for energy supply	owner			Increase in cost
72	Non-competitive pricing/quotes	owner			Increase in cost
73	Failure in energy supply	owner			Impossibility of building operation, increase in cost
74	Failure in energy efficiency measures	owner			Increase in cost
EXTERNAL RISKS					
75	Dependency on key suppliers	owner			Dependency on the prices of the suppliers, increase in cost
76	Failure of supplier to meet agreed operational standard	owner			Searching for other suppliers, increase in cost
77	Theft of assets from within the building and other security failures	owner			Damages, additional costs
78	High staff turnover, low staff base	owner			Clueless staff, costs for staff training
79	Building overoccupancy	owner			Obsolescence, additional costs for repairs
80	Political situation	owner			Changes in the requirements, additional costs
81	Terrorism	owner			Damage to the building, costs for repairs
FINANCIAL RISKS					
82	Increases in interest rates	owner			Increase in cost
83	Lack of future investment in capital	owner			Needs of funds, loans; additional costs
84	Increased financial liabilities	owner			Needs of funds, loans; additional costs
85	Disposal risk	owner			Additional costs

5.3.3. QUALITATIVE RISK ANALYSIS

The third step is to perform qualitative risk analysis to describe the extent of potential consequences and the likelihood that these consequences occur.

In this assessment the risks are grouped by phases of the whole life cycle and further by impacted area. Further steps are to determine the risk probability and risk impact and to use Probability and impact matrix to prioritize the risks. (Described in paragraph 4.3.2.)

Abbreviations used in the following table:

LH = likelihood, IM = impact, ORA = overall risk assessment, D&B = design & build, DBB = design-bid-build, CM = professional construction management, VL = very low, L = low, M = moderate / medium, H = high, VH = very high, LR = low risk, MR = moderate risk, HR = high risk, ER = extreme risk

Table 8: UPDATED RISK REGISTER – QUALITATIVE RISK ANALYSIS

ID	RISK	D&B			DBB			CM		
		LH	IM	ORA	LH	IM	ORA	LH	IM	ORA
DESIGN AND BIDDING STAGE										
ENVIRONMENTAL RISKS										
1	Incomplete environmental analysis	M	VL	LR	M	L	MR	M	VL	LR
2	Environmental regulations change	VL	M	LR	VL	M	LR	VL	M	LR
DESIGN RISKS										
3	Misunderstanding of task	M	H	ER	M	M	HR	M	M	HR
4	Insufficient information about the project	M	VH	ER	M	H	ER	M	H	ER
5	Owner involvement in design	VL	L	LR	M	L	MR	M	L	MR
6	Problems with design	M	VH	ER	VH	VH	ER	H	H	ER
7	Not efficient solution of design	M	H	ER	H	H	ER	M	H	ER
8	Incomplete design	M	H	ER	M	VH	ER	M	VH	ER
9	New design standard	VL	VL	LR	VL	VL	LR	VL	VL	LR
CONTRACT RISKS										
10	Type of contract	L	M	MR	L	M	MR	L	M	MR
11	Contract conditions	M	H	ER	M	H	ER	M	H	ER
12	Lack of cooperation between stakeholders	M	L	MR	L	L	LR	L	L	LR
13	Variations in price and foreign exchange	M	L	MR	M	L	MR	M	L	MR
PRE-CONSTRUCTION STAGE										
PROJECT MANAGEMENT RISKS										
14	Time for project preparation	VL	M	LR	VL	H	MR	VL	H	MR
15	Misunderstanding of project	M	H	ER	M	M	HR	M	M	HR
16	Insufficient information about the project	M	VH	ER	M	H	ER	M	H	ER
17	Estimating or scheduling errors	M	H	ER	M	H	ER	M	VH	ER
18	Lack of cooperation between stakeholders	M	L	MR	L	L	LR	L	L	LR

19	Inexperienced staff	M	H	ER	M	H	ER	M	M	HR
20	Stakeholders request late changes	M	H	ER	M	M	HR	M	M	HR
21	Experience with similar project	M	M	HR	M	M	HR	M	M	HR
22	Local communities pose objections	L	M	MR	L	M	MR	L	M	MR
23	New information required for permits	L	H	HR	L	H	HR	L	H	HR
PROCUREMENT STAGE										
CONSTRUCTION RISKS										
24	Subcontractors	M	H	ER	M	H	ER	M	H	ER
25	Material resources	M	L	MR	M	L	MR	L	L	LR
26	Stakeholders request late changes	M	VH	ER	M	VH	ER	M	H	ER
CONSTRUCTION STAGE										
CONSTRUCTION RISKS										
27	Time for project preparation	L	M	MR	L	H	HR	L	H	HR
28	Misunderstanding of project	M	H	ER	M	M	HR	M	M	HR
29	Insufficient information about the project	M	VH	ER	M	H	ER	M	H	ER
30	Estimating or scheduling errors	M	VH	ER	M	VH	ER	M	H	ER
31	Lack of cooperation between stakeholders	M	L	MR	L	L	LR	L	L	LR
32	Inexperienced staff	M	VH	ER	M	VH	ER	M	H	ER
33	Consultant or contractor delays	VL	L	LR	VL	M	LR	VL	L	LR
34	No control over staff priorities	L	M	MR	L	M	MR	L	L	LR
35	Changes during construction	M	VH	ER	M	VH	ER	M	H	ER
36	Building permit	VL	M	LR	VL	M	LR	VL	M	LR
37	Material resources	M	L	MR	M	L	MR	L	L	LR
38	Geological conditions	L	L	LR	L	L	LR	L	L	LR
39	Difficult technical solution	M	M	HR	M	M	HR	M	M	HR
40	Subcontractors	M	H	ER	M	H	ER	M	H	ER
41	Experience with similar project	M	M	HR	M	M	HR	M	M	HR
42	Losing critical staff at crucial point of the project	M	H	ER	M	H	ER	M	VH	ER
43	Insurance	M	M	HR	M	M	HR	L	M	MR
EXTERNAL RISKS										
44	Site access	L	L	LR	L	L	LR	L	L	LR
45	Historic site, endangered species or wetlands present	M	L	MR	M	L	MR	M	L	MR
46	New information required for permits	L	H	HR	L	H	HR	L	H	HR
47	Political situation	M	L	MR	M	L	MR	M	L	MR
48	Storm	VL	VH	HR	VL	VH	HR	VL	VH	HR
49	Labor shortage or strike	VL	H	MR	VL	H	MR	VL	H	MR
50	Terrorism	VL	M	LR	VL	M	LR	VL	M	LR
FINANCIAL RISKS										
51	Warranty	M	L	MR	M	L	MR	M	VL	LR
52	Liability of the bills	H	H	ER	H	H	ER	H	M	HR
53	Financing of the project	VL	H	MR	VL	H	MR	VL	H	MR
54	Financial situation of the contractor	L	VH	ER	L	VH	ER	L	VH	ER

ENVIRONMENTAL RISKS										
55	Environmental aspects	VL	L	LR	VL	L	LR	VL	L	LR
56	Contaminated soil	VL	L	LR	VL	L	LR	VL	L	LR
57	Contaminated water	VL	L	LR	VL	L	LR	VL	L	LR
58	Environmental regulations change	VL	M	LR	VL	M	LR	VL	M	LR
POST-CONSTRUCTION STAGE										
CONSTRUCTION RISKS										
59	Poor work quality	L	M	MR	M	M	HR	L	L	LR
60	Big amount of unremoved defects	L	M	MR	L	M	MR	VL	M	LR
61	Claims	M	L	MR	M	L	MR	L	L	LR
FINANCIAL RISKS										
62	Warranty	M	L	MR	M	L	MR	M	VL	LR
63	Financing of the project	VL	H	MR	VL	H	MR	VL	H	MR
64	Sum of the retaining money	L	H	HR	L	H	HR	L	M	MR

OWNER OCCUPANCY STAGE				
ID	**RISK**	**LIKELIHOOD**	**IMPACT**	**OVERALL RISK ASSESSMENT**
MAINTENANCE RISKS				
65	Lack of skilled maintenance labor	L	H	HR
66	Building fabric / component failure	M	M	HR
67	Poor quality maintenance regime	L	M	MR
68	Increased demands on M&E equipment	VL	L	LR
69	Unexpected plant and equipment obsolescence	VL	M	LR
ENERGY RISKS				
70	Increase in unit cost of energy	VH	M	ER
71	Increase in demand for energy supply	M	H	ER
72	Non-competitive pricing/quotes	VH	L	HR
73	Failure in energy supply	VL	M	LR
74	Failure in energy efficiency measures	L	L	LR
EXTERNAL RISKS				
75	Dependency on key suppliers	L	L	LR
76	Failure of supplier to meet agreed operational standard	M	L	MR
77	Theft of assets from within the building and other security failures	H	L	HR
78	High staff turnover, low staff base	M	M	HR
79	Building overoccupancy	L	L	LR
80	Political situation	M	L	MR
81	Terrorism	VL	M	LR
FINANCIAL RISKS				
82	Increases in interest rates	M	L	MR
83	Lack of future investment in capital	VL	M	LR
84	Increased financial liabilities	M	M	HR

85	Disposal risk	L	M	MR

5.3.4. QUANTITATIVE RISK ANALYSIS

The fourth step is to further analyse the high priority risks. The goal of this assessment is to estimate the frequency and the severity of losses endangering the project and prioritize the risks by their cost. (Described in paragraph 4.4.2.)

At that moment risks are prioritized and according to the assessment levels risks are divided into four groups: green – low risks; yellow – moderate risks; orange – high risks; red – extreme risks.

The further assessment is focused on the high risks and extreme risks.

The cost of this reconstruction project was 250 million CZK. The impact in percentage of total cost is estimated based on other studies of risk management[67,68].

In the table below (Updated risk register) there are described identified risks with their likelihood and expected monetary value.

Abbreviations used in the following table:

IM = impact, TC = total cost, D&B = design & build, DBB = design-bid-build, CM = professional construction management, LH = likelihood, EMV = expected monetary value, thsd. = thousands

Table 9: UPDATED RISK REGISTER – QUANTITATIVE RISK ANALYSIS

ID	RISK	IM (% of TC)	COST OF IM (in thsd. CZK)	D&B		DBB		CM	
				LH	EMV (in thsd. CZK)	LH	EMV (in thsd. CZK)	LH	EMV (in thsd. CZK)
DESIGN AND BIDDING STAGE									
DESIGN RISKS									
3	Misunderstanding of task	0.5	1,250	0.5	625	0.5	625	0.5	625
4	Insufficient information about the project	1	2,500	0.5	1,250	0.5	1,250	0.5	1,250
6	Problems with design	0.1	250	0.5	125	0.9	225	0.7	175
7	Not efficient solution of design	5	12,500	0.5	6,250	0.7	8,750	0.5	6,250
8	Incomplete design	1	2,500	0.5	1,250	0.5	1,250	0.5	1,250
CONTRACT RISKS									
11	Contract conditions	0.3	750	0.5	375	0.5	375	0.5	375

[67] DRNEK, Ondřej. *Risk Management in a Real Construction Project*.

[68] ŠEDIVÁ, Simona. *Risk Management in a Historical Reconstructions*.

PRE-CONSTRUCTION STAGE									
PROJECT MANAGEMENT RISKS									
15	Misunderstanding of project	1	2,500	0.5	1,250	0.5	1,250	0.5	1,250
16	Insufficient information about the project	1.5	3,750	0.5	1,875	0.5	1,875	0.5	1,875
17	Estimating or scheduling errors	1	2,500	0.5	1,250	0.5	1,250	0.5	1,250
19	Inexperienced staff	0.5	1,250	0.5	625	0.5	625	0.5	625
20	Stakeholders request late changes	2	5,000	0.5	2,500	0.5	2,500	0.5	2,500
21	Experience with similar project	3	7,500	0.5	3,750	0.5	3,750	0.5	3,750
23	New information required for permits	0.2	500	0.3	150	0.3	150	0.3	150
PROCUREMENT STAGE									
CONSTRUCTION RISKS									
24	Subcontractors	0,3	750	0.5	375	0.5	375	0.5	375
26	Stakeholders request late changes	3	7,500	0.5	3,750	0.5	3,750	0.5	3,750
CONSTRUCTION STAGE									
CONSTRUCTION RISKS									
27	Time for project preparation	1	2,500	0.3	750	0.3	750	0.3	750
28	Misunderstanding of project	3	7,500	0.5	3,750	0.5	3,750	0.5	3,750
29	Insufficient information about the project	2.5	6,250	0.5	3,125	0.5	3,125	0.5	3,125
30	Estimating or scheduling errors	1.5	3,750	0.5	1,875	0.5	1,875	0.5	1,875
32	Inexperienced staff	1	2,500	0.5	1,250	0.5	1,250	0.5	1,250
35	Changes during construction	2	5,000	0.5	2,500	0.5	2,500	0.5	2,500
39	Difficult technical solution	8	20,000	0.5	10,000	0.5	10,000	0.5	10,000
40	Subcontractors	0.5	1,250	0.5	625	0.5	625	0.5	625
41	Experience with similar project	5	12,500	0.5	6,250	0.5	6,250	0.5	6,250
42	Losing critical staff at crucial point of the project	0.2	500	0.5	250	0.5	250	0.5	250
43	Insurance	0.05	125	0.5	63	0.5	63	0.3	38
EXTERNAL RISKS									
46	New information required for permits	0.2	500	0.3	150	0.3	150	0.3	150
48	Storm	6	15,000	0.1	1,500	0.1	1,500	0.1	1,500
FINANCIAL RISKS									
52	Liability of the bills	0.1	250	0.7	175	0.7	175	0.7	175
54	Financial situation of the contractor	2	5,000	0.3	1,500	0.3	1,500	0.3	1,500
POST-CONSTRUCTION STAGE									
CONSTRUCTION RISKS									
59	Poor work quality	30	75,000	0.3	22,500	0.5	37,500	0.3	22,500
FINANCIAL RISKS									
64	Sum of the retaining money	2	5,000	0.3	1,500	0.3	1,500	0.3	1,500
OWNER OCCUPANCY STAGE									
ID	**RISK**	**IM (% of TC)**	**COST OF IM (in thsd. CZK)**	**LH**			**EMV (in thsd. CZK)**		

MAINTENANCE RISKS					
65	Lack of skilled maintenance labor	5	12,500	0.3	3,750
66	Building fabric / component failure	15	37,500	0.5	18,750
ENERGY RISKS					
70	Increase in unit cost of energy	1	2,500	0.9	2,250
71	Increase in demand for energy supply	2	5,000	0.5	2,500
72	Non-competitive pricing/quotes	0.5	1,250	0.9	1,125
EXTERNAL RISKS					
77	Theft of assets from within the building and other security failures	5	12,500	0.7	8,750
78	High staff turnover, low staff base	2	5,000	0.5	2,500
FINANCIAL RISKS					
84	Increased financial liabilities	2	5,000	0.5	2,500

5.3.5. RISK RESPONSES

The fifth step is to develop the options and the actions how to deal with each risk.

In the following table (Updated risk register) there are described identified risks with their response strategies.

Abbreviations used in the following table:

RO = risk owner, ORA = overall risk assessment, D&B = design & build, DBB = design-bid-build, CM = professional construction management / manager, C = contractor, S = subcontractors, O = owner

Table 10: UPDATED RISK REGISTER – RISK RESPONSES

ID	RISK	D&B		DBB		CM		RISK RESPONSE
		RO	EMV (in thsd. CZK)	RO	EMV (in thsd. CZK)	RO	EMV (in thsd. CZK)	
DESIGN AND BIDDING STAGE								
DESIGN RISKS								
3	Misunderstanding of task	C	625	O	625	CM	625	MITIGATE
4	Insufficient information about the project	O	1,250	O	1,250	O	1,250	MITIGATE
6	Problems with design	C	125	O	225	CM	175	MITIGATE / TRANSFER
7	Not efficient solution of design	C	6,250	O	8,750	CM	6,250	AVOID
8	Incomplete design	C	1,250	O	1,250	CM	1,250	MITIGATE / TRANSFER

CONTRACT RISKS								
11	Contract conditions	O/C	375	O/C	375	O / CM	375	MITIGATE
PRE-CONSTRUCTION STAGE								
PROJECT MANAGEMENT RISKS								
15	Misunderstanding of project	C	1,250	C	1,250	CM	1,250	MITIGATE
16	Insufficient information about the project	O	1,875	O	1,875	CM	1,875	MITIGATE
17	Estimating or scheduling errors	C	1,250	C	1,250	CM	1,250	TRANSFER
19	Inexperienced staff	C	625	C	625	CM	625	TRANSFER
20	Stakeholders request late changes	O	2,500	O	2,500	O / CM	2,500	MITIGATE
21	Experience with similar project	C	3,750	C	3,750	CM	3,750	MITIGATE / TRANSFER
23	New information required for permits	C	150	O	150	CM	150	MITIGATE
PROCUREMENT STAGE								
CONSTRUCTION RISKS								
24	Subcontractors	C	375	C	375	CM	375	TRANSFER
26	Stakeholders request late changes	O	3,750	O	3,750	O / CM	3,750	MITIGATE
CONSTRUCTION STAGE								
CONSTRUCTION RISKS								
27	Time for project preparation	C	750	C	750	CM	750	TRANSFER
28	Misunderstanding of project	C	3,750	C	3,750	CM	3,750	MITIGATE
29	Insufficient information about the project	O	3,125	O	3,125	CM	3,125	MITIGATE
30	Estimating or scheduling errors	C	1,875	C	1,875	CM	1,875	TRANSFER
32	Inexperienced staff	C	1,250	C	1,250	CM	1,250	TRANSFER
35	Changes during construction	O/C	2,500	O/C	2,500	CM	2,500	AVOID / MITIGATE / TRANSFER
39	Difficult technical solution	C	10,000	C	10,000	CM	10,000	MITIGATE / TRANSFER
40	Subcontractors	C	625	C	625	CM	625	TRANSFER
41	Experience with similar project	C	6,250	C	6,250	CM	6,250	MITIGATE / TRANSFER
42	Losing critical staff at crucial point of the project	C	250	C	250	CM	250	MITIGATE
43	Insurance	C	63	C	63	CM	38	MITIGATE
EXTERNAL RISKS								
46	New information required for permits	C	150	C	150	CM	150	MITIGATE
48	Storm	C	1,500	C	1,500	CM	1,500	AVOID / TRANSFER
FINANCIAL RISKS								
52	Liability of the bills	C	175	C	175	S	175	AVOID
54	Financial situation of the contractor	C	1,500	C	1,500	S	1,500	MITIGATE
POST-CONSTRUCTION STAGE								
CONSTRUCTION RISKS								
59	Poor work quality	C	22,500	C	37,500	CM / S	22,500	MITIGATE / TRANSFER
FINANCIAL RISKS								
64	Sum of the retaining money	C	1,500	C	1,500	S	1,500	MITIGATE
OWNER OCCUPANCY STAGE								
ID	**RISK**	**RO**			**EMV (in thsd. CZK)**			**RISK RESPONSE**
MAINTENANCE RISKS								
65	Lack of skilled maintenance labor	owner			3,750			MITIGATE / TRANSFER

66	Building fabric / component failure	owner	18,750	MITIGATE / TRANSFER
ENERGY RISKS				
70	Increase in unit cost of energy	owner	2,250	ACCEPT / AVOID
71	Increase in demand for energy supply	owner	2,500	MITIGATE
72	Non-competitive pricing/quotes	owner	1,125	ACCEPT / AVOID
EXTERNAL RISKS				
77	Theft of assets from within the building and other security failures	owner	8,750	AVOID / TRANSFER
78	High staff turnover, low staff base	owner	2,500	MITIGATE
FINANCIAL RISKS				
84	Increased financial liabilities	owner	2,500	MITIGATE

Risk treatment

The ability of the parties to influence project outcomes, including reduction of cost, creation of additional value, improvement of performance and flexibility to incorporate changes is much higher in the earlier conceptual and design stages of the project. Therefore, it is advisable to identify, assess and solve risk before the project will start. But not just at the beginning, the risks develop throughout the whole life cycle of construction; for this reason it is necessary to repeat the risk assessments.

The decision-making how to deal with risk should be chosen for each risk individually.

The risk treatment for risks listed in table 5 is described in detail below.

DESIGN AND BIDDING STAGE

ID 3 – Misunderstanding of task

The chosen risk treatment is to mitigate the risk. The big problem could occur already at the beginning of the project with the incomprehension of the project task; therefore it is necessary that all parties are properly informed. That could be solved by meetings of stakeholders.

ID 4 – Insufficient information about the project

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method the owner should accurately and clearly specify his project goals and requirements; they should be generally described in the contract.

ID 6 – Problem with design

The chosen risk treatment is to mitigate or transfer the risk. The project documentation should be done by some reputable design company. Or the owner could transfer the risk by selecting the project delivery method. When the owner decides to choose the design and build, the risk will be transferred to the contractor and the contractor will handle them at his own expenses.

ID 7 – Not efficient solution of design

The chosen risk treatment is to avoid the risk. Inefficient solution brings problems not only in construction phase but also in others, especially in the operational stage where the consequences could be serious. It is necessary to eliminate it.

ID 8 – Incomplete design

The chosen risk treatment is to mitigate or transfer the risk. The construction cannot start without complete project documentation, it causes the delay. The project documentation should be done by some reputable design company and the owner should ensure that the design will be done on time. Or he could transfer the risk by selecting the project delivery method. When the owner decides to choose the design and build, the risk will be transferred to the contractor and the contractor will handle them at his own expenses.

ID 11 – Contract conditions

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method there is a need for parties to agree on the contract conditions.

PRE-CONSTRUCTION STAGE

ID 15 – Misunderstanding of project

The chosen risk treatment is to mitigate the risk. It is necessary that all parties are properly informed about their project work. That could be solved by meetings of stakeholders.

ID 16 – Insufficient information about the project

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method the owner should accurately and clearly specify his project goals and requirements; they are generally described in the contract.

ID 17 – Estimating or scheduling errors

The chosen risk treatment is to transfer the risk. The estimating and scheduling errors could have huge impact on project delay and particularly on increase in cost. That could

be resolved by transferring the risk from the owner to other party; the transference could be done by selecting the right project delivery method and type of contract.

ID 19 – Inexperienced staff

The chosen risk treatment is to transfer the risk. When talking about the hotel construction the owner usually do not have much experience with construction or experienced staff; therefore it is advisable to transfer these risks to other party by selecting the right project delivery method.

ID 20 – Stakeholders request late changes

The chosen risk treatment is to mitigate the risk. Stakeholders' late requests for changes are very common; it is appropriate to in advance organize more meetings with stakeholders to reduce the late changes.

ID 21 – Experience with similar project

The chosen risk treatment is to mitigate or transfer the risk. The reconstruction of historical building is always demanding and the selecting of the experienced contractor is main key to success. The owner could transfer the risks by the selecting right project delivery method.

ID 23 – New information required for permits

The chosen risk treatment is to mitigate the risk. It is advisable to detect the necessary information in advance and monitoring the requirements.

PROCUREMENT STAGE

ID 24 – Subcontractors

The chosen risk treatment is to transfer the risk. The coordination of subcontractors could be demanding, therefore it is appropriate to transfer the risk to person or company with more experience by the selecting the project delivery method.

ID 26 – Stakeholders request late changes

The chosen risk treatment is to mitigate the risk. Stakeholders' late requests for changes are very common; it is appropriate to in advance organize more meetings with stakeholders to reduce the late changes.

CONSTRUCTION STAGE

ID 27 – Time for preparation

The chosen risk treatment is to transfer the risk. The owner could transfer the risks by the selecting right project delivery method to the contractor.

ID 28 – Misunderstanding of project

The chosen risk treatment is to mitigate the risk. It is necessary that all parties are properly informed about their project work. That could be solved by meetings of stakeholders.

ID 29 – Insufficient information about the project

The chosen risk treatment is to mitigate the risk. Regardless of select project delivery method the owner should accurately and clearly specify his project goals and requirements; they are generally described in the contract.

ID 30 – Estimate or scheduling errors

The chosen risk treatment is to transfer the risk. The estimating and scheduling errors could have huge impact on project delay and particularly on increase in cost. That could be resolved by transferring the risk from the owner to other party; the transference could be done by selecting the right project delivery method and type of contract.

ID 32 – Inexperienced staff

The chosen risk treatment is to transfer the risk. When talking about the hotel construction the owner usually do not have much experience with construction or experienced staff; therefore it is advisable to transfer these risks to other party by selecting the right project delivery method.

ID 35 – Changes during construction

The chosen risk treatment is to avoid or mitigate or transfer the risk. It is appropriate to in advance organize more meetings to reduce the late changes. By some type of contract some risks of changes could be transfer to the contractor.

ID 39 – Difficult technical solution

The chosen risk treatment is to mitigate or transfer the risk. This project is conversion of historical building, so a lot of problems could occur during the reconstruction. And it could require the difficult technical solution. It is necessary to conduct architectural and historical research. The owner could transfer the risk to the experienced contractor.

ID 40 - Subcontractors

The chosen risk treatment is to transfer the risk. The coordination of subcontractors could be demanding, therefore it is appropriate to transfer the risk to person or company with more experience by the selecting the project delivery method.

ID 41 – Experience with similar project

The chosen risk treatment is to mitigate or transfer the risk. The reconstruction of historical building is always demanding and the selecting of the experienced contractor is main key to success. The owner could transfer the risks by the selecting right project delivery method.

ID 42 – Losing critical staff at crucial point of the project

The chosen risk treatment is to mitigate the risk. Losing critical staff could have huge impact but this can be prevented by well training of the whole project team and that the information about project is recorded and shared.

ID 43 – Insurance

The chosen risk treatment is to mitigate the risk. The contractor should have insurance of the construction against unusual events such as fire, flood etc. The insurance company takes the responsibility.

ID 46 – New information required for permits

The chosen risk treatment is to mitigate the risk. It is advisable to detect the necessary information in advance and monitoring the requirements.

ID 48 - Storm

The chosen risk treatment is to avoid or transfer the risk. It is necessary to ensure the providing of regular updates of weather conditions that there could be possibility to change the plan. The risk could be also transfer to the third party like insurance company.

ID 52 – Liability of the bills

The chosen risk treatment is to avoid the risk. In the contract there are usually described fines for overdue payments. The owner should insure that the payments will not be after due date.

ID 54 – Financial situation of the contractor

The chosen risk treatment is to mitigate the risk. Already in the bidding phase the owner should find out the credibility of the contractor.

POST-CONSTRUCTION STAGE

ID 59 – Poor work quality

The chosen risk treatment is to mitigate or transfer the risk. The owner should select experience contractor and ensure that the fines for the defects are specified in the

contract. With the selecting of the project delivery method the owner transfers the risk of poor quality to the contractor.

ID 64 – Sum of the retaining money

The chosen risk treatment is to mitigate the risk. The retaining money serves as protection of the owner and “insures” that the contractor will finish all the works, remove all the defects and clear backlog.

OWNER OCCUPANCY STAGE

ID 65 – Lack of skilled maintenance labor

The chosen risk treatment is to mitigate or transfer the risk. The owner should ensure staff training and more intensive inspection of works. Also he could transfer the risk to the company providing the facility management.

ID 66 – Building fabric / component failure

The chosen risk treatment is to mitigate or transfer the risk. The owner should ensure effective maintenance regimes and regular condition assessments. The risk could be transfer to the other party like insurance company.

ID 70 – Increase in unit cost of energy

The chosen risk treatment is to accept or avoid the risk. The owner should continually monitor the market prices. But within the energy cost there are not many options.

ID 71 – Increase in demand for energy supply

The chosen risk treatment is to mitigate the risk. The owner should ensure that the efficiency measures are working correctly.

ID 72 – Non-competitive pricing / quotes

The chosen risk treatment is to accept or avoid the risk. The owner should continually monitor the market prices. But within the energy cost there are not many options.

ID 77 – Theft of assets from within the building and other security failures

The chosen risk treatment is to avoid or transfer the risk. The owner should ensure regular asset auditing and strengthen security system. The risk could be transfer to the other party like insurance company.

ID 78 – High staff turnover, low staff base

The chosen risk treatment is to mitigate the risk. The owner should enhance relationships with management and workforce; ensure better training and commitment to investment in the workforce.

ID 84 – Increased financial liabilities

The chosen risk treatment is to mitigate the risk. The owner should have effective financial management protocol and minimise the need for loans.

5.3.6. RISK CONTROL

Sixth step is monitoring of the risks. Risk control is based on continuous risk monitoring and assessments throughout the whole life cycle of construction. It is necessary to identify new risks which could have a huge impact on the project or the current but with different impact. It is also advisable to perform audits to know what effectiveness the risk approach has.

5.4. FINDINGS

This chapter showed risk management in practise, there were presented the individual processes of project risk management. For this purpose there were used two specific construction projects of hotel building, the first project was the construction project of hotel building in Prague, the second project was the conversion of the House of Trade union services into hotel building in Ostrava. The both projects were analysed by the same approach.

The first step was to identify people, groups, or organizations that could have affected the project. There were identified 22 stakeholders involved in each project. The second step was to identify risks, the risk owner who takes responsibility for the risk and their impact on the project. There were identified 87 risks throughout the whole life cycle of the construction in each project. The third step was to perform qualitative analysis to describe the extent of potential consequences and the likelihood of each consequence. The fourth step was to further analyse the high priority risks and the goal of the assessment was to estimate the frequency and the severity of losses endangering the project. The fifth step was to develop the options and the actions against each risk. The last step was risk monitoring and controlling the risk throughout the whole life cycle of the construction.

The main aim of this research was determined the delivery method which would had been the best solution for projects of hotels. From the beginning there were showed the differences between risks of three most used project delivery methods – design and build,

design-bid-build and construction management. In the process of risk identification there were described risk owners of each risk for each delivery method. In the process of risk qualitative assessment there were characterized the consequences and the likelihood of each risk in different delivery methods. The risks were split into four categories – low risks, moderate risks, high risks and extreme risks. The further quantitative analysis was focused on the high and extreme risks which required immediate attention. The purpose of quantitative assessment was to estimate the severity of losses endangering the project.

The purpose of the estimation of all high and extreme risks was to compare the project delivery methods based on monetary losses. The total expected monetary values for delivery methods are summarized in the following tables.

Table 11: TOTAL EXPECTED MONETARY VALUE – HOTEL CONSTRUCTION

Description	D&B	DBB	CM
Total expected monetary value in millions CZK	65,555	88,844	65,912

Table 12: TOTAL EXPECTED MONETARY VALUE – HOTEL RECONSTRUCTION

Description	D&B	DBB	CM
Total expected monetary value in millions CZK	83,162	100,762	83,187

Based on the above tables it is clear that the project delivery method design-bid-build is not suitable. The methods design & build and construction management have the similar results, which bring us to make decision between these two. From the process risk identification there are known risk owners; the most of high and extreme risks in design & build method are already transferred to the contractor, accordingly the owner does not need to deal with their impact. On the other hand in the method of construction management the risk owner is mostly also someone other than the owner, in this case it is construction manager; but in the case of the professional construction management the risk owner is not responsible in full extent.

From the perspective of the owner's risk management the best solution of delivery method is design and build. The most of risks are transferred to the contractor and the owner will face only a few of them.

6. CONCLUSION

The aim of this diploma thesis was to analyse relation and extent of risks in each stage of the project to achieve desirable results of the project by defining and implementing management processes of the project risk and to determine which of the delivery methods would had been the best solution for projects of hotels.

The introductory chapter (1) presented the background and justification of the research, including its aim and objectives.

The next three chapters were focused on theoretical knowledge necessary to achieve the aim and objectives of the research.

The second chapter (2) of the thesis was focused on construction projects. The chapter was divided into four parts. The first part was about construction life cycle and the description of the individual phase of the construction life cycle. The segmentation of the construction project helps the management, planning and control. The second part of this chapter was about life cycle issues, it contained one of the fundamental parts of a decision-making such as whole life cycle costing. The third part of this chapter was the description of the three most used project delivery methods in private sector such as design-bid-build, design & build and professional construction management. The fourth part of this chapter was focused on types of contracts such as lump sum contract, cost-plus-fee contract, guaranteed maximum price contract and unit cost contract.

The third chapter (3) of the thesis was focused on project stakeholder management. This chapter presented the processes of the stakeholder management such as stakeholder identification, planning stakeholder management, managing stakeholder engagement and stakeholder engagement control. To know all interested parties, internal and external to the organizational, is one of the key processes of the successful project management.

The forth chapter (4) of the thesis was focused on risk management. This chapter presented the processes of the risk management such as planning risk management, risks identification, qualitative risk analysis, quantitative risk analysis, risk responses and risk control. The identification of the risks is the main process of the risk management, risk identification determines what might happen that could affect the objectives of the project and how those things might happen. Risk qualification is the process of distinction of the identified risks; this analysis uses words to describe the extent of potential consequences and the likelihood that these consequences occur. Further analysis of the risk

management is risk quantification; it is the process of estimation of the frequency and the severity of losses endangering the project. Risk responses are the process of developing the options and the actions; each risk requires convenient response how to face it. Risk control is process of the monitoring and controlling the risks throughout the whole project life cycle. As the project progresses through its life cycle the new risks could develop, therefore there is a need of iteration of risk management processes.

The fifth chapter (5) was focused on practical application of the theoretical knowledge from the previous three chapters. This entire chapter was focused on **the first research objective – to apply risk management tools and techniques to real construction project**. This chapter was divided into four parts. The first part was focused on the project context, approach of the application. The second and the third were focused on performance in the real construction projects. And the last part was focused on research findings.

The parts of subchapters – risk identification (5.2.2 and 5.3.2), risk assessments (5.2.3, 5.2.4 and 5.3.3, 5.3.4), risk responses (5.2.5 and 5.3.4) were focused on **the second research objective – to analyse relation and extant of risks in each stage of project life cycle** and **the third research objective – to compare risks of possibly used delivery methods**.

The first project (5.2) used in this research was the construction project of hotel building in Prague. The first step of the performance of risk management was the identification of stakeholders and their role in the project. There were identified 22 stakeholders associated with this construction project (see Table 1). The second step was the identification of the risks, the risk owners and their impact on the project. There were identified 87 risks throughout the whole life cycle of the construction and the risk owners were described for each of possibly used project delivery methods - design & build, design-bid-build and professional construction management (see Table 2). The third step was performance of the qualitative assessment. The purpose of this analysis was to determine the risk probability and risk impact for each risk in different project delivery method. By using the Probability and impact matrix the risks were prioritized and divided into four groups according to the assessment levels (see Table 3). The assessment levels are low risks, moderate risks, high risks and extreme risks. For further analysis there were used high and extreme risks. The fourth step was performance of the quantitative analysis. The goal of the assessment was to estimate the frequency and the severity of losses endangering the project (see Table 4). The estimation of the impact is very complicated and based on experience of experts. The impact in this assessment was

estimated with aid of other studies of risk analysis. The fifth step risk responses was to find out the most effective solution how to deal with high and extreme risks (see Table 5). In this part there were described strategies in detail for these risks. The last step risk control was to monitor and assess risks throughout the whole life cycle.

The second project (5.3) used in this research was the reconstruction project of the House of Trade union services into hotel building in Ostrava. For this project there was used the same approach as for the first project. There were identified 22 stakeholders and described with their role in the project (see Table 6). The further step was identification of risks; there were identified 87 risks throughout the whole life cycle of the construction (see Table 7). Risk identification was followed by risk assessments. The first assessment was qualitative; identified risks were analysed and grouped by their assessment level – low risks, moderate risks, high risks and extreme risks (see Table 8). The second assessment was quantitative; this analysis was focused on the high and extreme risks (see Table 9). In the next step there were described response strategies for the high risks and extreme risks (see Table 10). The last step risk control was to monitor and assess risks throughout the whole life cycle.

The last part of the fifth chapter (5.4) was focused on the findings of the risk management application on real projects and on **the fourth research objective – to determine a delivery method which would be the best for projects of hotels**. Based on the total expected monetary values from the quantitative analysis from both project (see Table 11 and Table 12) there was determined the most advantageous delivery method from the perspective of the owner's risk management. The advised delivery method for projects of hotels was design & build.

This diploma thesis summarized the theoretical and practical knowledge related to risk management. All objectives of the research had been successfully achieved, ranging from the fundamental of the application of risk management processes to the real construction projects to the determining of a delivery method.

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